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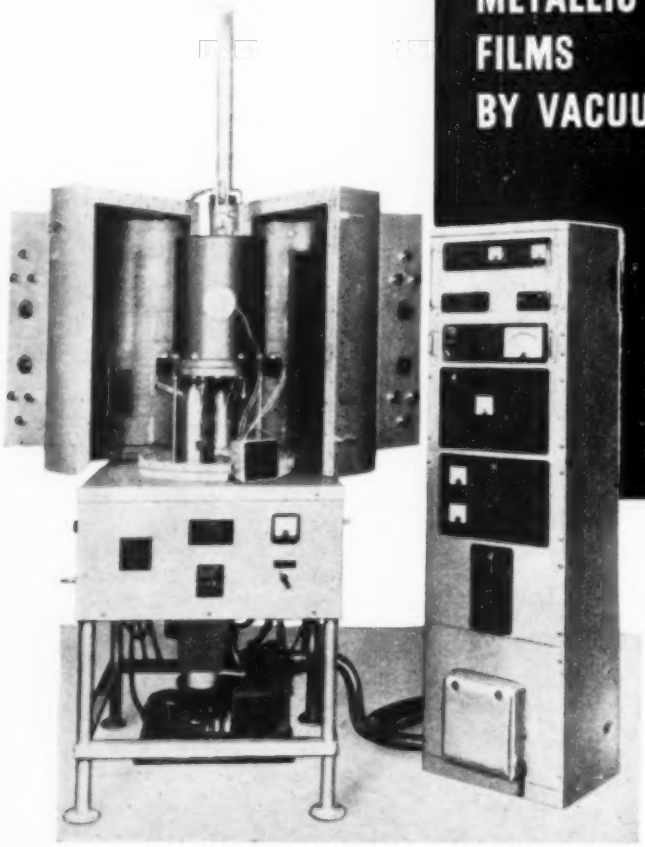

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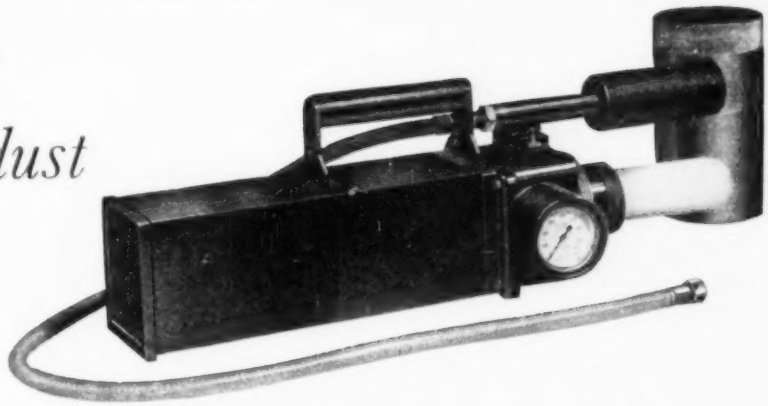

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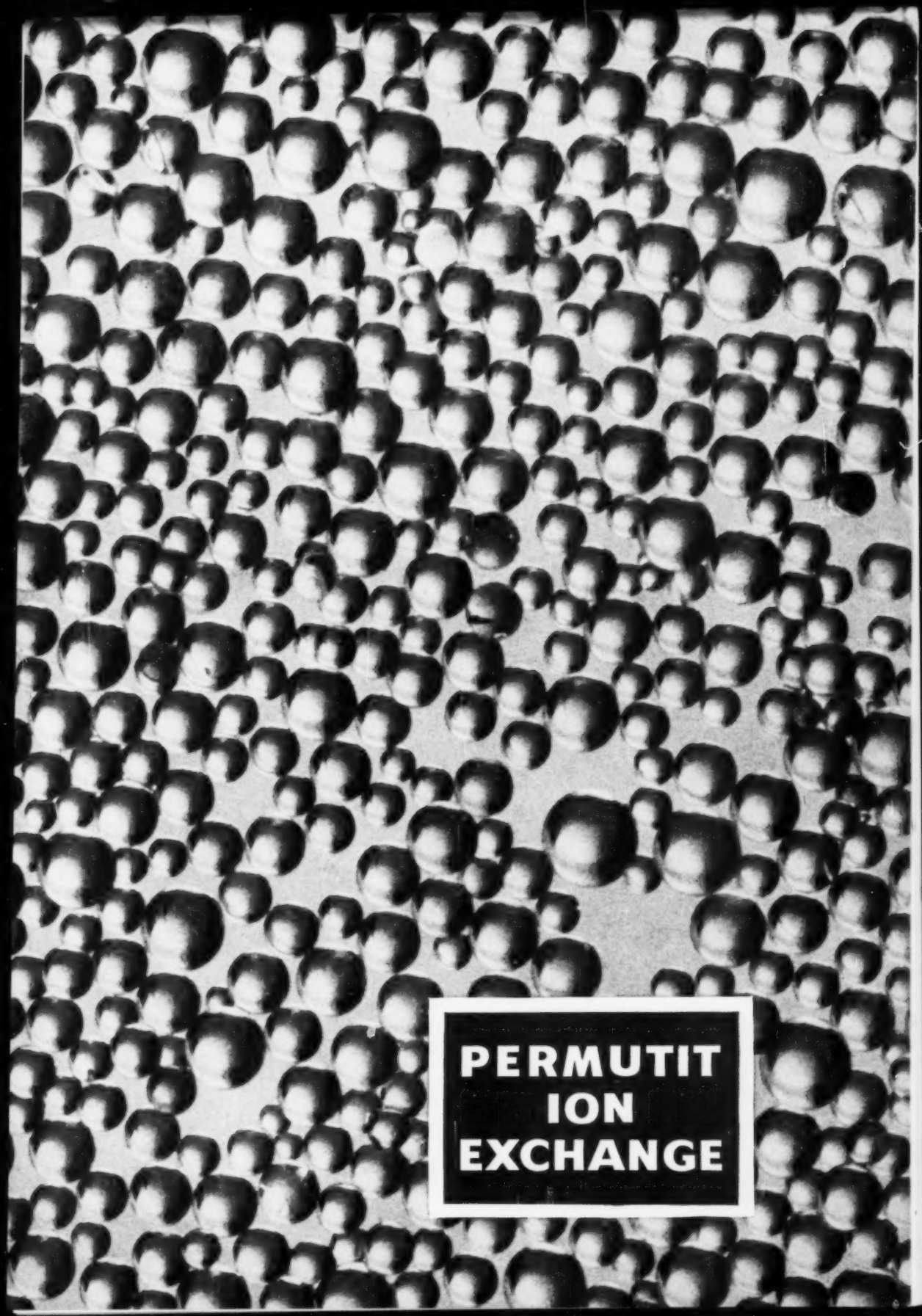
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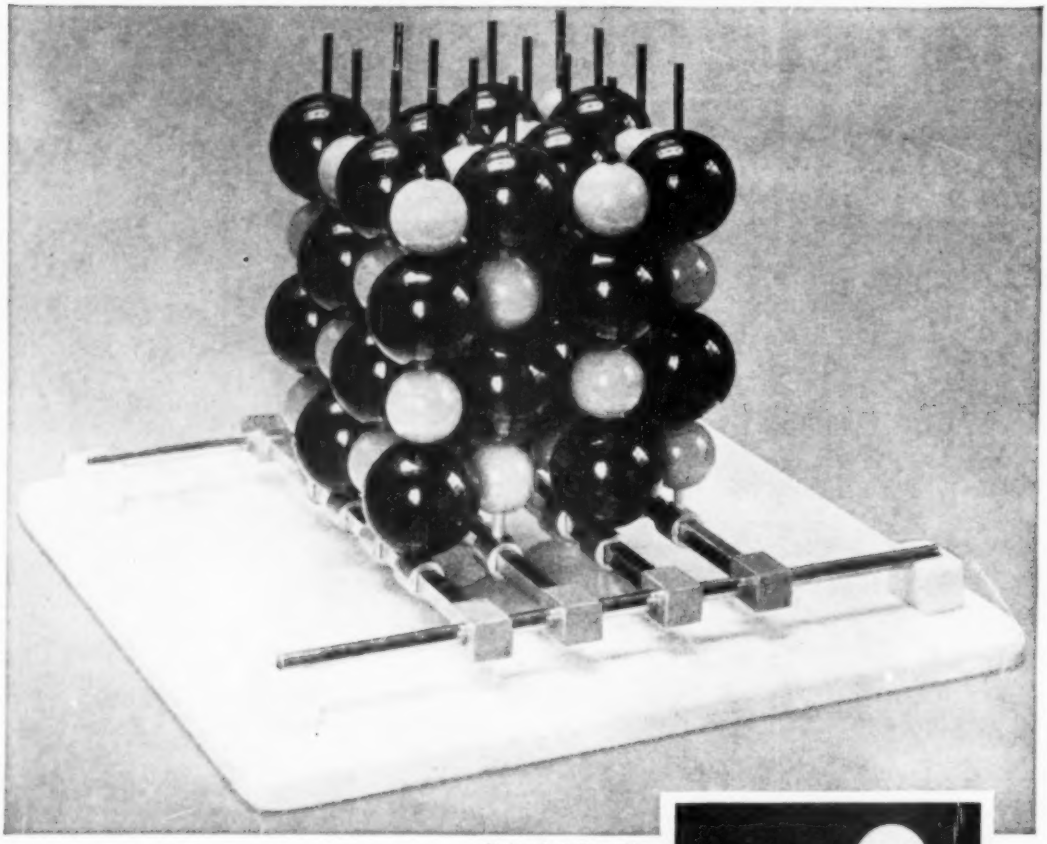

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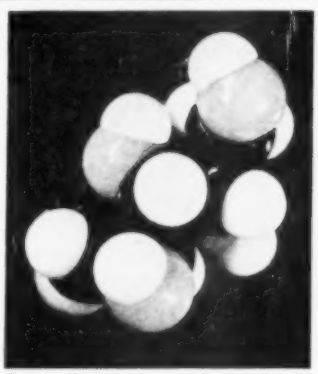

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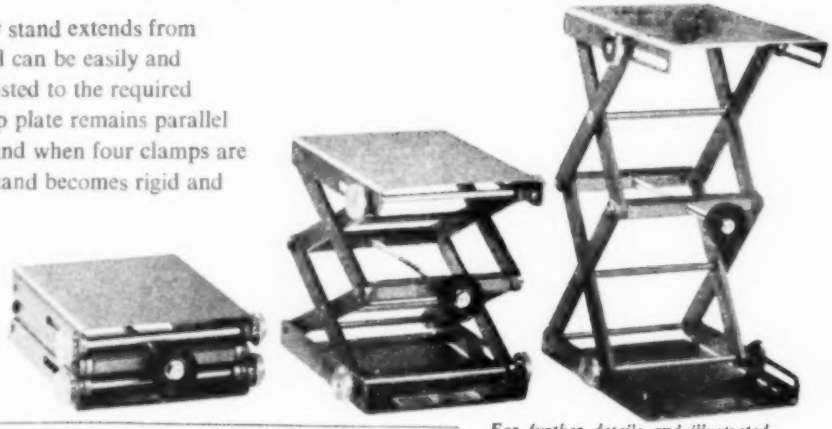

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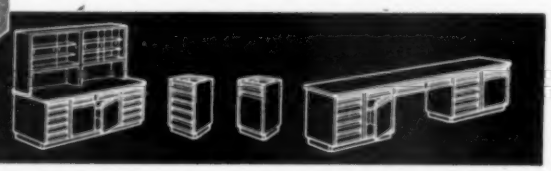

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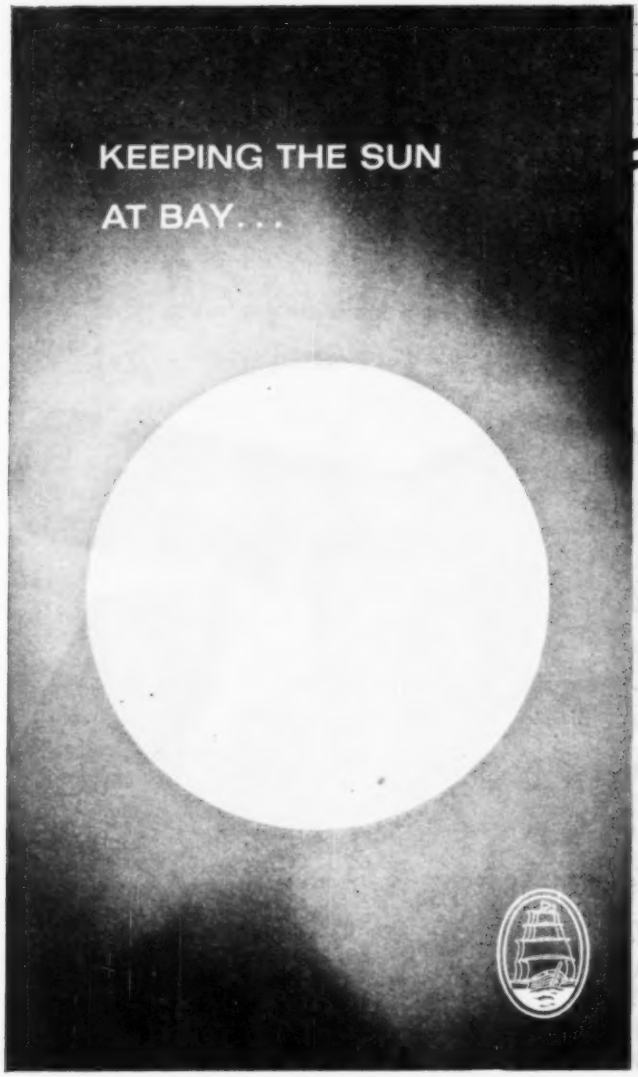

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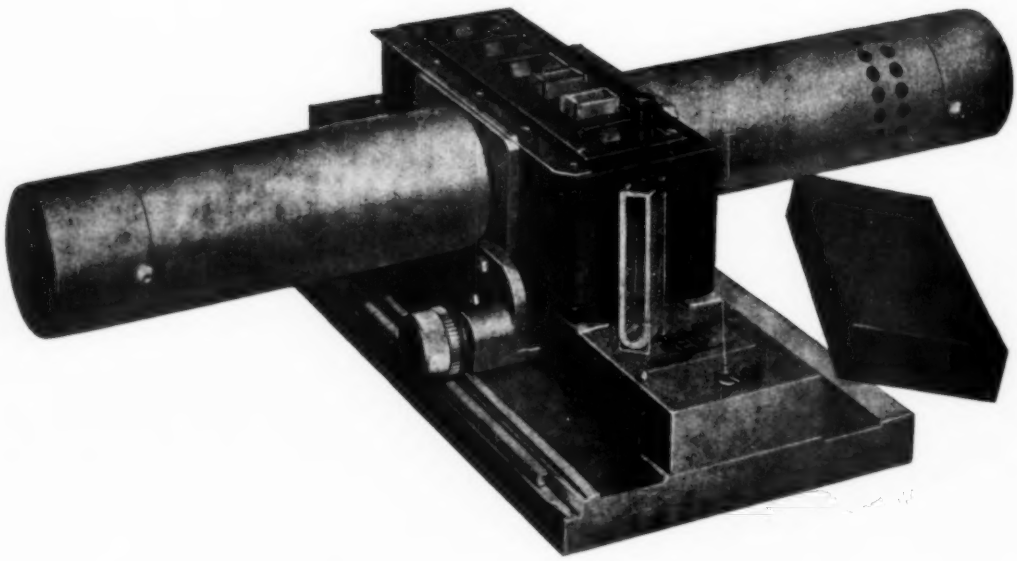

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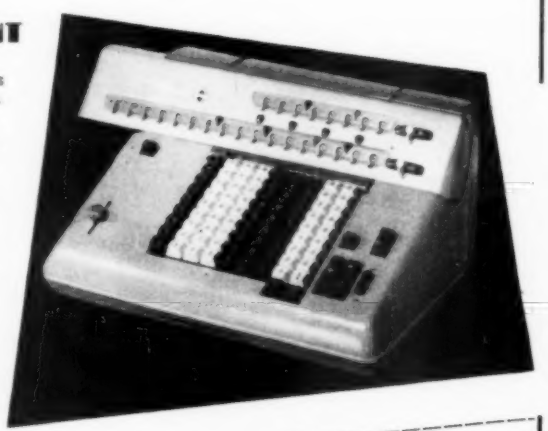

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SUPPORT FOR FUNDAMENTAL RESEARCH

IN reprinting, as part of its tenth anniversary celebrations, *Science: the Endless Frontier*, by Dr. Vannevar Bush, the National Science Foundation included an introduction by its director, Dr. A. T. Waterman, summarizing the extent to which, in the fifteen years since the report was published, its recommendations have been realized. Dr. Waterman recognizes that all the problems relating to the understanding and nature of basic research have not been solved, but he can point to a steady upward trend in Federal funds for basic research and to an increase in the number and diversity of Government sources providing such support. Some progress has also been recorded in research activities within the Government, and the establishment of the President's Science Advisory Committee is in line with the recommendation in the report that a Science Advisory Board should be created. Medical research was another major emphasis in Dr. Bush's report, especially basic research in this field, and here again there has been a rapid increase in available funds; and the organization established—the Division of Biological and Medical Sciences and the National Institutes of Health—meet and even go beyond that visualized in the report. In defence research, however, the situation is rather different from that visualized by Dr. Bush, but the substance of his principal recommendations is probably met by the arrangements with the universities continued by the Office of Scientific Research and Development, the generous support given to basic research by the three Armed Services, and by the number of leading scientists, both within the Department of Defense and in outside institutions, who are dealing with defence problems.

Something has also been done to improve the position with regard to international relations in science, notably by the appointment of scientific attachés, of a Science Adviser to the Secretary of State, and in such matters as visas, attendance at scientific conferences, etc. Notable progress has been made in implementing the recommendations in the chapter discussing the renewal of scientific talent, and, compared with a recommended programme of 29 million dollars by the fifth year, the National Science Foundation by 1960 had obligations for scientific personnel and education totalling more than 65 million dollars.

Recommendations relating to the dissemination of scientific information seem largely to have been fulfilled, and Dr. Waterman's introduction directs particular attention to the development of the National Science Foundation, the establishment of which was put forward as a principal means of implementing other major recommendations in the report. Its structure is substantially that recommended by Dr. Bush, and the Foundation has sought to observe the five basic principles enunciated by him. First, it seeks to ensure the continuity and stability that are needed in basic research; secondly, particular attention has been paid to the calibre of those serving either on its staff or as advisers or consultants; thirdly, it operates no laboratories of its own, but promotes research through grants or contracts; fourthly, it has kept to a minimum any conditions required of academic institutions; finally, it has not found its responsibilities to the President and Congress incompatible with independence and freedom of operation. While, however, Dr. Bush visualized the Foundation as the sole support in the Government of basic research, this has been far from the fact, and of about 200 million dollars for basic research in 1956, some 72 million dollars went through the Department of Defense, 45 million dollars through the Atomic Energy Commission, 26 million dollars through the National Institutes of Health, and the remainder was distributed through other Departments as well as the Foundation. In 1956, its fifth year, its funds totalled only 16 million dollars compared with 122·5 million dollars suggested by Dr. Bush, but in its ninth year, 1960, they had risen to 159·2 million dollars. Dr. Waterman considers that the organization provides the desirable flexibility as well as opportunity for expansion, but points out that there is still insufficient public appreciation of the importance of science and of education as distinct from technology.

This introduction by Dr. Waterman may be appropriately set beside the statement which introduces the Foundation's tenth annual report, covering the year ended June 30, 1960, which has now been published (see p. 494), and the chapter in the report, "Stimulating the National Research Effort", which reviews the Foundation's programmes for promoting basic research and education in the sciences in the broad context of the Federal Government's response to the challenge thrown down by the President's Science Advisory Committee in its report two years ago entitled *Strengthening American Science*. First, the progress of scientific research is considered, including the conduct of basic research, methods of support, facilities for research, participation by the United States in international programmes of research, notably in the International Geophysical Year and the continuing programmes of International Geophysical Co-operation and in the Antarctic, in which United States participation is developed and co-ordinated by the National Science Foundation, with recommendations from the National Academy of Sciences, and the communication of scientific information. Next, steps taken to assist the development of the individual scientists are out-

lined, such as the provision of fellowships, projects to train more science teachers and measures to improve the curriculum; and thirdly, those factors which determine the most favourable conditions for the growth of institutions for teaching and for research are considered.

On the first, the review emphasizes the extent to which the Federal Government now provides support for basic research; the man-power engaged in such research is to be found in some 450 universities and research institutions. It is interesting to note that, in discussing methods of support, the need for university co-operation is recognized. Like the Advisory Council for Scientific Policy in Britain, the National Science Foundation has come to recognize that desirable projects may cut across departmental boundaries and may even involve inter-university co-operation, and is now making grants of a broader type. As examples, one to the University of Pennsylvania is in support of research applying concepts of chemistry and physics to the biological problem of regulation of metabolism within the cell, while another will permit a concerted attack, at the Massachusetts Institute of Technology, on the problem of the production and nature of plasmas.

Here, and in regard to the provision of adequate facilities for research, the National Science Foundation and the Advisory Council for Scientific Policy appear to be working on similar lines; but the Foundation appears to be much more vigorous in its efforts to promote the communication of scientific information. Divergence is even more marked in regard to efforts to deal with the shortage of science teachers and the improvement of curricula, and it will be noted that in the Director's statement which precedes the review, Dr. Waterman suggests that for the future the main concern of the Federal Government in planning more effectively for science and technology should be in the field of education. Nevertheless, the Foundation's experience confirms that of the Advisory Council on Scientific Policy on the importance of sufficient Government support to research institutions and universities to ensure a proper balance of activities, and on the need to identify the critical areas of basic research and see that they are adequately supported; as well as to ensure that the possibilities of co-operative effort are not neglected, while, on the other hand, the weaknesses of massive, concerted efforts are also recognized and avoided.

Generally, the review suggests that Federal support of basic research and education in the sciences is sufficiently vital and flexible in the United States, though it is suggested that the situation calls for general aid to the universities on some such lines as those provided by the University Grants Committee in Britain. The Federal Government, however, is regarded as now better prepared for the discharge of its responsibilities in science, although stronger support for basic research is still required and the country's potential in science and technology is far from being realized. More effort, too, is needed in training scientists and engineers, and this is seen as a matter of widespread public recognition, understanding and appreciation of the importance of intellectual and scholarly activity and of the pursuit of excellence in all fields of intellectual endeavour.

Some of these points are emphasized even more strongly in Dr. Waterman's prefatory statement already mentioned. The National Science Foundation has a responsibility for the continuing study and analysis of the United States' scientific research and development potential, including research facilities, scientific man-power and education for science. Inquiries initiated seven years ago have now revealed trends that throw light on the present situation as well as assist long-range planning. It was these inquiries that led Dr. Waterman to the conclusion already quoted that the field of education should be the principal concern, and it is clear from his remarks that the United States is well ahead of Great Britain in action taken to remedy a situation that has become equally menacing to both countries. Admittedly, in the United States, little progress has been made in providing adequate salaries and career prospects for secondary school teachers of science, but in the United States standards have been tightened and critical thought devoted to the curricula and to improving the training of teachers and the content of courses. Beginnings of course have been made in Britain, as in the appointment by the University Grants Committee of a committee to study comparatively undergraduate teaching methods and practices; but concerted action is still needed and the situation requires urgent attention, just as it calls for tactful but firm handling.

Nevertheless, Dr. Waterman points out that these inquiries have shown that American institutions of higher learning are in critical need of assistance, especially in their graduate schools and other professional training centres. He comments on the effect of a widened gap between academic and industrial salaries, and on the fact that for several years fewer than 50 per cent on average of competent research workers in colleges and universities have received adequate support for the research they wished to pursue. A source of funds is needed that will enable a university to exercise initiative, judgment and competence in meeting its own needs, and it is this situation presumably that has led the Foundation to suggest, as already noted, a fresh look at the University Grants Committee system of Britain. Dr. Waterman does not wish to see the universities too dependent on the Federal Government for funds for research or training in research, and he stresses the way in which provision of uncommitted funds to universities, while from one point of view less effective than support of research projects, fosters the growth and independence of the institution and its contribution to research and education.

Support of basic research, Dr. Waterman suggests, should be regarded as a form of investment from which the returns in trained man-power are assured and research returns of definite value to the economy are statistically certain, and may more than repay the entire investment. Again, he recognizes the acute

problem presented by the high cost of research equipment, more especially in certain critical fields of study, which are by no means always easy to identify, and which may require special scrutiny and decision on more than a scientific basis alone. Nevertheless, so far as the overall progress of science is concerned, he insists that the judgment of the active research worker should be the determining factor, and that the central planning and direction which are inevitable in development would be detrimental to scientific advance.

Generally, Dr. Waterman agrees that in spite of repeated emphasis on the importance of basic research, in the United States support has not been forthcoming on a scale sufficient to enable such research to hold its own in relation to the larger and seemingly more pressing problems of development. Although the position may be somewhat better in Great Britain, the experience of the National Science Foundation during the past decade affords no ground for complacency. The problems confronting the Foundation are similar in many ways to those facing the Advisory Council for Scientific Policy, and it is apparent that there are certain respects in which the Minister for Science might well take steps to see that these problems are tackled with more urgency and determination, and that the necessary co-ordination and financial support are forthcoming, even if it involves raising issues at Cabinet-level. Finally, the reader of this report can scarcely fail to note how much in it supports the argument advanced in the report, *Increasing the Effectiveness of Western Science*, for making the utmost possible use of possibilities of international co-operation in the attack on such major problems as space research, oceanography, polar research and the like.

THE PROCESSES OF DEVELOPMENT

The Biochemistry of Development

By Prof. Jean Brachet. (International Series of Monographs on Pure and Applied Biology. Division: Modern Trends in Physiological Sciences, Vol. 2.) Pp. xii + 320. (London and New York: Pergamon Press, 1960.) 65*s*. net.

IN the years since the Second World War, biochemistry, which began with an interest in how living systems maintain themselves, has begun to find itself in a position to tackle the much more difficult question of how they come into being. Chemical embryology may be said to have become a separate branch of study with the publication of J. Needham's great three-volume treatise in 1931. Even that was mainly concerned with the maintenance metabolism of embryos, and it was only with the publication of the same author's *Biochemistry and Morphogenesis* in 1942, and J. Brachet's *Embryologie Chimique* in 1944, that the study of the chemical processes by which development itself takes place acquired a massive impetus. Brachet's classical book was revised and translated into English in 1950, and since then he has published another extensive survey of similar ground, in his *Biochemical Cytology* of 1957. In the present book, he returns to embryology. The work is, as he points out in the foreword, to be considered as a summary of the advances that have been made since the last edition of his *Chemical Embryology*. In general, it follows the plan of that book, with successive chapters on gametogenesis, fertilization, cleavage, two chapters on the chemical embryology of invertebrate and of vertebrate eggs, nucleo-cytoplasmic interactions during morphogenesis, and finally, the biochemistry of differentiation.

Prof. Brachet modestly discounts any claim to treat these subjects in a complete and exhaustive manner, emphasizing that he is concerned only with reviewing the recent advances. However, as we have learnt to expect from this author, the subjects which he chooses to treat include nearly all the topics which have attracted the attention of embryologists in recent years. Moreover, they are discussed on the basis of his well-known combination of extremely wide reading and considerable, original, and largely unpublished, observations by himself and his collaborators. The result is a book which has, on one hand, the merits of a very valuable work of reference, but which is also something much more, in that it presents a most stimulating general synthesis of the field as it is seen by one of the most active contributors to it. The recent period in embryology has been remarkable for the number and power of the new technical methods which have been made available for the investigation of developing systems. We have seen, in particular, the introduction of refined biochemical methods for studying the nucleic acids, and such technical advances as the use of tracers, electrophoresis, immunological methods, the electron microscope, nuclear transplantation, and so on. Brachet and workers in his laboratory have themselves used many of these methods, and he writes with real authority about them.

Perhaps Brachet's most characteristic contribution to our general theories of embryonic development is his emphasis on the importance of gradients of ribonucleic acid content in various regions of the egg and embryo. In this book also, the evidence on this subject is fully discussed, and a number of as yet unpublished observations are described. To me it seems that, although there is undoubtedly a great deal of importance in Brachet's concept of nucleic acid gradients, the conception does not do adequate justice to the undoubted existence of an enormously elaborate system of specific types of ribonucleic acid and protein. Indeed, biochemistry is probably not yet equipped to tackle this aspect of the matter. It is primarily the study of genetics which leads us to realize that any given cell probably contains hundreds, if not thousands, of different species of ribonucleic acid and protein. If any criticism is to be offered of Brachet's book, it is that one would like to have seen more genetics in it. Perhaps, however, it is unreasonable to ask for so much. A satisfactory synthesis between genetics and biochemical embryology is what we are all seeking, and one can scarcely demand of an author that he should provide something that no one has yet been able to formulate. We have enough to be grateful for in a work which deals with the whole biochemical side of development in a manner which is both thorough and also controversial enough to be stimulating.

C. H. WADDINGTON

POLAROGRAPHY

Advances in Polarography

Proceedings of the Second International Congress held at Cambridge, 1959. Edited by Ian S. Longmuir. Vol. 1: Pp. xv+1–407. Vol. 2: Pp. ix+408–803. Vol. 3: Pp. vii+804–1204. (London and New York: Pergamon Press, 1960.) £15 per set of three volumes.

THESE three volumes constitute the collected papers of the second International Congress on Polarography, held at Cambridge in 1959, in honour of the seventieth birthday of Prof. Jaroslav Heyrovsky, Nobel laureate. Many hundreds of investigators have published papers in this field of science since Heyrovsky's first research paper on this subject in 1924, and the passing years have brought not only a tremendous increase in our knowledge of the general theoretical principles governing polarography but also many important practical advances in the design and sensitivity of the related instrumentation. The applications of polarography have been outstandingly successful in the analytical and industrial fields, and have been extended and diversified to include investigatory work of the greatest importance to the biological, agricultural and medical sciences.

These proceedings of the Congress are published almost entirely in English, although the three volumes do contain a few papers where the text is in French or German, a circumstance which serves as a useful reminder to the more insular among us that science is, indeed, international, and that a modicum of linguistic ability has many advantages to the up-to-date scientist.

The volumes abound in theoretical excursions by international experts which must prove of the greatest value to the academic teacher or pure researcher. Ilkovic discusses his celebrated equation for the mean diffusion current in d.c. polarography, and detailed comments on the equations of Matsuda and Koutecky are also included in papers by Koutecky and other authors. H. Irving provides an authoritative paper on the stability of metal complexes and gives a detailed thermodynamic treatment of step equilibria in solution: P. Delahay relates electrode process phenomena and polarographic theory: R. Brdicka presents an extensive theoretical treatment of kinetic currents and J. Heyrovsky gives a mathematical treatment of the principles of oscillographic polarography.

Recent advances in the instrumental techniques of polarography are dealt with in numerous papers by acknowledged experts. G. C. Barker and G. W. C. Milner describe the development for trace analyses of the highly sensitive square-wave polarograph and of the single-sweep oscillographic and a.c.-pulse instruments. H. M. Davies, J. Seaborn and H. I. Shalyosky present papers on the application of the differential cathode-ray instrument to 'subtractive' and 'comparative' polarography. Indeed, it is impossible in a review such as this to mention more than a small number of the eminent scientific authors who have made lucid and detailed contributions on newer instrumentation.

The three volumes abound in examples of practical analytical applications. The determination of trace impurities in semi-conductor materials; the estimation of dissolved oxygen; the reduction of pertechnetate ions; the polarography of molten nitrates, of chelate complexed ions, of ergothioneine and of various biologically important compounds are but a few of the experimental applications which receive detailed treatment.

Z. P. Zagorski presents a valuable paper on reference electrodes; the uses of solid micro-electrodes are discussed by several authors, and T. R. Mueller, C. L. Olson and R. N. Adams review the employment of boron carbide and carbon electrodes in voltametry.

The ramifications of the science of polarography within the overlapping fields of chemistry, biology and medicine are now so extensive that only a comprehensive collection of erudite papers of this type by many expert investigators could hope to present a realistic picture of present advances in practice and in theory. In these three volumes is an attempt at this herculean task, and the aim of the compiler has been largely achieved.

D. T. Lewis

MEDICINE OF THE THORAX

Brompton Hospital Reports

Vol. 28, 1959. (A Collection of Papers by Members of the Staffs of the Hospitals for Diseases of the Chest—Brompton Hospital and the London Chest Hospital—and of the Institute of Diseases of the Chest.) Pp. xii+258. (London: Lloyd-Luke (Medical Books), Ltd., 1960.) 15s. net.

THE contents of this volume, which is as attractively produced as all its predecessors have been, maintain the high standard we have learned to expect from these reports. It is sad that this one should have to begin with a memorial notice to Sir Robert Arthur Young, who served both the staff and patients at the Brompton Hospital for so long. Joining the staff in 1905, he was one of the first physicians to realize the possibilities of thoracic surgery, and the long history of his life's work is admirably summed up here by the publication of the late Sir Gordon Gordon-Walker's address given at the memorial service. To read this address is to realize that Young was not only a great medical man but also a great human character.

The rest of the volume contains 16 articles on a variety of aspects of thoracic disease. Drs. L. H. Capel and J. Smart discuss in two papers aspects of effort intolerance; Drs. K. M. Citron, A. W. Frankland and J. D. Sinclair report on inhalation tests of bronchial hypersensitivity in pollen asthma, Drs. J. Pepys, R. Augustin and A. B. Paterson on common antigenic components of mycobacterial extracts and Dr. H. A. Fleming on differential lung function in atrial septal defect. Dr. Lynne Reid describes the connective tissue septa in the adult human lung and Dr. D. Ranger discusses the dangers of streptomycin with particular reference to its vestibular toxic effects. Dr. Paul Wood contributes two articles on pulmonary hypertension with reference to the vasoconstrictive factor and to reversed central shunt.

Surgery is represented by two articles by Sir Clement Price Thomas on the surgical treatment of pulmonary tuberculosis and on conservative and extensive resection for carcinoma of the lung, while J. B. Johnston and P. H. Jones discuss the treatment of carcinoma by lobectomy and sleeve resection

of the main bronchus and W. K. Pallister describes a new endobronchial tube for the left lung. The value of the surgical contributions is greatly enhanced by the two articles by Sir Russell C. Brock, one of which is his Bradshaw Lecture on the present position of cardiac surgery (with its tribute to the work of Sir Charles Ballance and the part he played in the death of the superstition that the heart is untouchable), and the other is on direct operations for the correction of Fallot's tetralogy. Dr. J. G. Scadding contributes an opening article on the principles of definition in medicine, with special reference to chronic bronchitis and emphysema.

The bibliographies of all these articles are valuable, but would be more so if the titles of the papers quoted were given. The volume concludes with a list of papers published by members of the staff of the Brompton Hospital between August 1958 and July 1959 and with author and subject indexes to volumes 1–28. GEOFFREY LAPAGE

ELEMENTS OF PHYSICAL CHEMISTRY

Elements of Physical Chemistry

By Samuel Glasstone and Prof. David Lewis. Pp. v+758. (London: Macmillan and Co., Ltd., 1960.) 60s. net.

STUDENTS and teachers of physical chemistry will need no introduction to the *Elements of Physical Chemistry* by Glasstone and Lewis, the second edition of the book first produced by Glasstone in 1945. The major change in the new edition is a re-ordering of the chapters, so that after an initial outline of the properties of gases the reader is led through the realms of thermodynamics. This has the advantage of enabling such phenomena as vaporization of liquids and solids to be treated thermodynamically when first met, rather than phenomenologically as in the earlier edition. The molecular nature of matter is introduced in the billiard-ball approximation, in the chapter on the gaseous state via the kinetic theory, the more intimate details of the structure of atoms and molecules, and the direct evidence for their existence being left until a later stage. From this point onwards the book follows much the same well-established lines as the earlier edition. However, a new chapter on nuclear chemistry has been included. New material has been incorporated in all the chapters, to bring the book into line with contemporary developments.

The increased attention given to two of the basic theories of physical chemistry, namely wave mechanics and statistical mechanics, is welcome, although I feel that the section on the Schrödinger equation could well have been extended to indicate the way in which eigen values fall naturally out of the assumptions of the theory.

The book is written in such a way as to be readily understood by the student commencing the subject; moreover, the references given at the ends of the chapters should stimulate him to further reading of the subject. These references have been extended to include well-known review journals, as well as those to the *Journal of Chemical Education*, which were the sole source of additional information in the first edition.

To understand physical chemistry completely the student needs to acquire the facility to manipulate the results of experimental observation as well as the basic concepts. Development along these lines is encouraged by a new selection of problems at the end of each chapter, designed to set the reader thinking, and to develop his ability to interpret experimental results within the framework of physico-chemical theory.

The book is very well and attractively produced, and the figures have been well chosen to bring home to the reader the points in question. There is no doubt, in my mind, that the part played in the teaching of physical chemistry by the first edition will be more than adequately filled by the second.

A. MACCOLL

BRITISH FOOD ANALYSIS

The Composition of Foods

By Dr. R. A. McCance and Dr. E. M. Widdowson: Privy Council. Medical Research Council Special Report Series, No. 297. (London: H. M. Stationery Office.) 1960. (Third revised edition of Special Report No. 235.) Pp. viii+252. 30s. net.

THIS book of tables, giving the composition of a comprehensive selection of foods commonly eaten in Britain, is the third edition of the Medical Research Council Special Report Series No. 235, originally published in 1939. In 1942 the first edition was revised, the revisions including a change in the method of calculating the calorie value of carbohydrate, and the addition of 'National' 85 per cent flour and bread to the foods analysed. The second edition, published in 1946, included some other foods introduced into the nation's diet as a result of the Second World War. Both editions are well known to nutrition workers. The tables were the result of analytical work carried out under the direction of Prof. McCance since 1925. They showed the important organic and mineral constituents, with the exception of vitamins, of most of the foods in common use in Great Britain. Foods were analysed not only in the raw state but also as prepared for the table. The composition of many cooked dishes was given.

The basis of the third and latest edition remains the same. However, some foods no longer generally consumed have been omitted, and some of the many new proprietary foods which have appeared on the market since the War have been added. More than 100 new foods, including cereal preparations, soft drinks, sweets and alcoholic beverages, figure in this edition. Changes in the composition of various proprietary foods have made it necessary to revise values previously given.

Important and useful additions are two new tables showing the vitamin and amino-acid content of foods. The vitamin values are derived from assays made by other workers, while the amino-acid figures are a combination of the authors' own results and those of other workers.

In its revised form this well-known work will no doubt continue to serve nutrition workers and dietitians, retaining an honoured place among various other food composition compilations, national

and international. The bulk of the tables is based on analyses of food samples carried out by the authors themselves, the results being given, for the main constituents, to the first decimal place. While such figures are, of course, accurate with respect to the samples analysed, they are not necessarily fully representative of the foods in question. Users of the tables should not forget that the composition of fresh foods varies widely even when variety and growing and harvesting conditions are uniform. Change in water content, for example, will obviously alter the whole composition of the food. All food composition tables, however carefully prepared, can in effect serve only as a guide in calculating the values of foods and meals. JOYCE DOUGHTY

FREE RADICAL TRAPPING

Formation and Trapping of Free Radicals

Edited by Arnold M. Bass and H. P. Broida. Pp. xvi+522. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1960.) 16 dollars.

ATOMS and free radicals, which normally react rapidly with surrounding molecules, can be 'trapped' in inert solids; if, for example, solutions in organic glasses are photolysed or products from a gas discharge are condensed at low temperatures. Free radicals have long been postulated as reaction intermediates, but only recently have many attempts been made to produce directly detectable concentrations of them in solids. That development has been rapid is shown by the size of this book. In 1954, seven laboratories independently published preliminary reports, their interest being mainly in determination of structures of radicals; in 1956, because of the slight possibility of production of sufficient concentrations of free radicals for use as rocket fuels, an intensive research programme was started at the National Bureau of Standards in Washington (under the direction of Dr. H. P. Broida).

Now that this burst of activity is over, research will proceed more slowly; this book will provide the background for the necessary period of consolidation. It begins with an excellent historical chapter by F. O. Rice, and there follow several chapters on methods of preparation and detection of trapped radicals. This approach, instead of arrangement by substances studied, is not easy to justify in the present state of knowledge and leads to considerable inconvenience—for example, data on trapped nitrogen atoms are scattered through eight of the sixteen chapters. However, it prevents the book from being a collection of research papers, and forces both authors and readers to reconsider the experimental problems of the field; indeed a certain amount of data relevant to the feasibility of trapping radicals appears here for the first time (Chapter 4).

A wide range of related fields and possible applications of free-radical trapping are dealt with in the later chapters. Some of these ("Rocket Propulsion") are highly speculative, others ("Radicals in Biological Processes") contain a great deal of background information and relatively few results; a shortening of the book, if accompanied by a reduction in the price, would certainly have been a great advantage. However, the editors' claim that this is a truly interdisciplinary field must be accepted, and among the new research workers for whose reference this book is written the spectroscopist will be glad to find a chapter on X-ray studies, and the biologist an elementary explanation of the application of electron-spin resonance, all in one volume.

B. BROCKLEHURST

A FRENCH LEXICON OF PLANT FORMATIONS

Les Formations Végétales et Paysages Ruraux

Lexique et Guide Bibliographique. Par G. Plaisance. (Publié avec l'aide du C.N.R.S.). Pp. 418. (Paris: Gauthier-Villars, 1959.) 3,000 francs.

LANDSCAPE, vegetation types and plant formations, as caused by factors of climate and soil and modified by man to suit his varied needs of food, pasturage and building, are basic factors in the evolution of languages and the history of civilization. Their ancient popular terminology has so often been the basis of place names and family names, and as such is studied by linguists, historians and geographers. In recent times they have become the special field of the botanical sciences of ecology, plant geography and phytosociology, which have introduced a disconcerting multitude of new words and phrases for the purposes of definition and classification.

To gather together the words and terms of several principal languages and continents for landscape, vegetation types and plant formations, from those of ancient dialects to the jargon of contemporary ecologists, has been the task of the author of this remarkable and fascinating dictionary. In the main *Lexique* each word, after definition, is given synonyms, examples of derivatives and main bibliographical references. After this there are special indexes of place names and family names derived from such words (for example, Fresnay (*frênaie*); Lafayette (*hêtraie*)); a trilingual, columnar lexicon for French, German and English terms; independent English and German indexes; another index, of botanical names; a vocabulary of technical terms used in ecology, plant geography and phytosociology; and, finally, a very extensive bibliography. The work is illustrated with small photographs and a number of maps. The maps of France showing the distribution, for example, of the many different dialect words for *hêtraie*, beech-wood, originating in fagetum, or of the great variety of words for expressing *défrichement*, are of absorbing interest.

Naturally, the work is strongest on the French side, and students of other nationalities will soon find defects and omissions, or will criticize the arrangement. I looked in vain, for example, for English 'down' and 'dune', and not enough attention has been given to recent Spanish publications and to Spanish words: for example, *pasto*, *pastizal*, *prado* and *pradera*, which appear in so many papers of keen, contemporary, Spanish agronomists should have been distinguished.

Nevertheless, every English ecologist and forester—one is tempted to say, every educated person—should examine this book, if only for repeated casual enjoyment and instruction.

N. Y. SANDWITH

Spot Tests in Organic Analysis

By Prof. Fritz Feigl. Sixth, enlarged and revised English edition. Translated by Prof. Ralph E. Oesper. Pp. xx+675. (Amsterdam: Elsevier Publishing Company; London: D. Van Nostrand Company, Ltd., 1960.) 65*s*.

THIS book is a revised and extended edition of Prof. Feigl's celebrated work on the application of the spot-test identification techniques to organic compounds of many different types. Translated by Prof. R. E. Oesper, of the University of Cincinnati, Ohio, the text of this sixth edition is lucidly presented in a most readable manner, with large legible print on good paper.

The individual items in the sections dealing with tests for functional groups, tests for individual groups, practical applications, etc. have been almost doubled in number when compared with the fifth edition. Extensive detail is given in addition relating to the identification of polymeric materials, synthetic rubbers and fibres, vitamins, antibiotics, and various pharmaceutical preparations. Each chapter carries an extensive bibliography of references, and the volume ends with a tabular summary of the limits of identification attained with macro-drop (0·05 ml.) investigations involving the application of specific spot-tests to solutions of those elements, groups and compounds which have been given detailed treatment in the text.

The working laboratory methods for spot-test analyses are illustrated by clear, diagrammatic representations of the apparatus employed, and the actual test procedures for individual cases are described with much attention to experimental detail.

This volume will be as welcome to students and to professional analytical chemists as its predecessors have been, and is yet another attempt to keep abreast of the ever-growing research, development and interest in this absorbing field.

D. T. LEWIS

Ciba Foundation Symposium on Hæmopoiesis

Cell Production and its Regulation. Edited by G. E. W. Wolstenholme and Maeve O'Connor. Pp. xii+490. (London: J. and A. Churchill, Ltd., 1960.) 60*s*. net.

IN recent years important advances in experimental hæmatology have been made, particularly by the use of radioisotopes and cell-transfusion techniques. These advances are amply reflected in the sixteen papers presented at the Ciba Foundation symposium on hæmopoiesis. The stimulating discussions which followed each paper are also recorded.

The dynamics of hæmopoiesis is a conspicuous feature of this book. Attention is focused on the problem of the primitive stem-cell, the production and fate of lymphocytes, and the inter-relationship of lymphoid and myeloid tissues. Factors which regulate the production and release of blood cells are also discussed. The subjects considered include: (1) granulocytopoiesis in human and animal bone marrows studied by radioisotopes; (2) hæmopoiesis following cell transfusions into irradiated animals; (3) the construction, from experimental data, of models illustrating the kinetics of erythrocyte production, lymphocyte formation in the thymus, and plasma cell production in lymph nodes; (4) humoral factors in hæmopoiesis, including erythropoietin, a leucocytosis-inducing factor and batyl alcohol; methods are described for the assay of erythropoietin, including the use of transfusion-induced polycythæmia to study erythropoiesis; and the mobilization of vitamin B_{12} reserves is described following acute blood loss; (5) observations on the patho-physiology of human leukæmic cells, certain findings contrasting with conventional views of the leukæmic process.

The Ciba Foundation is to be congratulated on its latest publication. The papers and their clinical implications will be of considerable interest to clinical and research hæmatologists. The book contains much that is topical in hæmatological research, including observations upon human material.

P. F. HARRIS

Unity and Diversity in Biochemistry

An Introduction to Chemical Biology. By Marcel Florkin. Translated from the French by T. Wood. (International Series of Monographs on Pure and Applied Biology. Division: Modern Trends in Physiological Sciences, Vol. 1.) Pp. xiii+397. (London and New York: Pergamon Press, 1960.) 70*s*. net.

THIS monograph is presented as a collection of essays in which Prof. Florkin first reviews "the biochemical facts common to living beings", and then discusses biochemical differences between species. The treatment of unity in metabolic processes (Parts 1–4) is concise, yet complete enough to be of value to the general reader who wants an introduction to the present state of biochemical knowledge. Part 1 is a lavishly illustrated catalogue of the more widely distributed constituents of plants and animals. This collection is perhaps too detailed for an introduction to chemical biology (the structures of thirty-one carotenoids are shown), and most readers would welcome more comments on the relationship between structure and biological function. Part 2 includes a thoughtful discussion of thermodynamic aspects of biochemistry and a classification of enzymic reactions. Chemists and biologists will probably find Parts 3 and 4 the most rewarding in this book. These describe many of the reaction sequences which provide materials and energy for growth and survival of plants and animals.

In restricting a discussion of biochemical diversity to fifty-seven pages (Part 5) the author has been able to illustrate his arguments with only a few of the possible examples; comparative aspects of oxygen transport are considered in great detail. There is a welcome attention to biochemical differences between tissues of a single organism. Biochemical aspects of taxonomy and evolution are discussed briefly. Part 6 deals with the interaction of plants and animals with each other and with their inorganic environment, and concludes with the suggestion that loss of phosphorus to the sea may make life on the continents "a mere episode between two eras of marine existence".

Not everyone will agree with the author's choice of examples and references, but no other book deals with this wide range of topics so concisely, and the reader without biochemical training should find this a useful introduction to chemical aspects of biology.

M. R. ATKINSON

THE HÆMOGLOBIN PARTICLES

CHEMICAL AND GENETIC ASPECTS OF THEIR STRUCTURE*

By DRS. G. BRAUNITZER, N. HILSCHMANN, V. RUDLOFF, K. HILSE, B. LIEBOLD and R. MÜLLER

Max-Planck-Institut für Biochemie, Munich

THIS article presents a summary of work on the primary structure of human hæmoglobin A which was begun five years ago in the Max-Planck-Institut für Biochemie; the results have been published during the past two years in various publications, and we wish to summarize and discuss them here.

The hæmoglobin particle is composed of four peptide chains, two identical α- and β-chains[1]. Human hæmoglobin consists of the Val-Leu-type (the α-chain[1-3]) and of the Val-His-Leu-type (the β-chain[1,4]). Our investigations were conducted on the main component of normal adult human hæmoglobin. In order to elucidate its chemical fine-structure we have split the globin particle with trypsin after denaturation with urea[5]; as first shown by Moore, Hirs and Stein[6] with ribonuclease, this enzyme is the simplest method of splitting a protein into a discrete number of definite breakdown products. For the separation of a peptide mixture we have developed a new procedure employing an anion exchange resin ('Dowex 1X2')[7,8] and pyridine acetate as a volatile ninhydrin-negative buffer. The essential principle of the method is that the separation depends only on the charge and also that peptides of very long chain-length can be eluted from the column. Since this method does not require desalting, it saves a considerable amount of labour (Fig. 1). The purification of the peptides is achieved by high-voltage electrophoresis and paper chromatography. By use of these procedures all the breakdown products of globin, which come from the α- as well as from the β-chain[9-12], could be separated, isolated and characterized quantitatively, by means of the automatic apparatus of Spackman, Moore and Stein (Beckman Instruments, Fullerton, Calif.). By these means the exact amino-acid composition of all tryptic breakdown products, with the exception of the three cysteine peptides, could be determined. The cysteine peptides could be separated and purified only after oxidation with performic acid. The amino-acid composition of these breakdown products will still have to be established more precisely, since destruction during oxidation is not ruled out. The knowledge of the exact amino-acid composition of these peptides is of primary importance for work on the amino-acid sequence still to be done, but not for the questions to be discussed here.

In extension of these investigations we have also developed a new, systematic procedure which makes possible the determination of the relative position of the tryptic peptides within the chain[14,15]. This is achieved almost systematically by splitting tryptic peptides with pepsin and by splitting those peptic peptides containing lysine and arginine with trypsin. A schematic presentation of the method is illustrated in Fig. 2. In this way identical peptides can be obtained which originate from the same section of the peptide chain, from which the sequence of the tryptic peptides can be concluded without difficulty.

In this manner the twenty-seven tryptic peptides of human hæmoglobin—thirteen from the α- and fourteen from the β-chain—could be assigned unambiguously to their positions within the peptide chains, and the partial formula of the α- and β-chains of the main component of normal adult human hæmoglobin could be established. In order to obtain a deeper insight into the primary structure of the hæmoglobin particle, the amino-acid sequence of the tryptic peptides was investigated. For this purpose conventional chemical (dinitrophenol method[16], Edman degradation[17,18], hydrazinolysis[19-21]) and enzymatic methods were employed. All the sequence studies were subjected to continuous control by quantitative analysis. For these controls a simplified amino-acid analyser (apparatus from Bender and Hobein, Munich)[22] was used. Up to the present, we have been able to fix the positions of about two-thirds of the amino-acid residues.

Homologous Architecture of the Chains

Comparison of the tryptic peptides of the α- and β-chain already shows that several breakdown

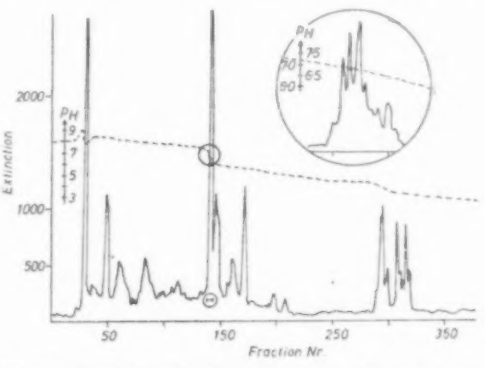

Fig. 1. Chromatography of peptic peptides of the α-chain on 'Dowex 1 X 2'. Experimental conditions: 1 per cent collidine, 1 per cent pyridine acetate *p*H 8·4. Gradient 1: 0·1 per cent acetic acid. Gradient 2: 2 *N* acetic acid; 50 *μM* protein. Column, 150 cm. × 3 cm.; temperature, 35°; flow-rate, 80 ml. per hr.

* Substance of a paper presented to the Hæmoglobine-Structure Workshop on December 14, 1960, of Endicott House, Massachusetts Institute of Technology, Boston, Mass.

products of both chains are identical or very similar; free lysine can be isolated from both, which is evidence of a lys-lys-sequence; moreover, the peptides Ala-His-Gly-Lys, Gly-His-Gly-Lys, Tyr-His, Tyr-Arg also show similarities. It became clear after determination of the position of the tryptic peptides within the chain and especially after establishing the amino-acid sequence within these peptides that the two chains are constructed in a homologous fashion[23]. They behave, with respect to each other, like proteins of different species.

In order to facilitate comparison, we have placed both chains together in Fig. 3. As can be seen, a large number of identical and homologous sequences occur in both chains. It is noteworthy that the basic amino-acids lysine and arginine occur at very similar positions in both chains: it is already apparent from sequence analysis that corresponding sections of the chain bear the same net charge. Both chains contain a basic centre, although the β-chain contains one additional basic residue:

(α) Lys-Gly-His-Gly-Lys-Lys (56–61)
(β) Lys-Val-Lys-Ala-His-Gly-Lys-Lys (61–66)

It is of further interest that the cysteine in both peptide chains—as one can tell from present investigations—is located in the last third of the chain.
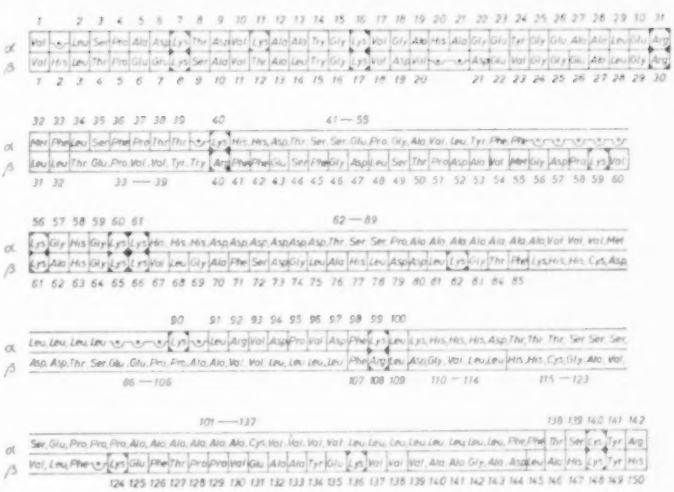
Fig. 3. The homologous structure of the α- and β-chains of the main compound of the normal adult human hæmoglobin. The homologous and identical sequences of the α- and β-chains of human adult hæmoglobin have been placed under one another. The sequence blanks resulting from such a comparison have been left free. The amino-acid residues the positions of which have been established are boxed in, thus [Ala]. Those residues the positions of which have not yet been fixed are represented in their sequence of elution from the amino-acid analyser, for example, Ala

The 'Blanks' in the Sequence

The individual homologous sequences of the α- and β-chain can only be made to match by omitting several amino-acids from an opposing position[23]. For example, the histidine in position 2 of the β-chain appears to have no partner in the α-chain. The homologous structure of the two chains can only be preserved by omission of this amino-acid: or, in other words, the α-chain has a 'blank' in the sequence in the equivalent position. The β-chain shows a similar behaviour in that it likewise possesses no partners for the amino-acids His-Ala (position 20–21) in the α-chain. There can be no doubt that the sequences (α) 56–61 Lys-Gly-His-Gly-Lys-Lys and (β) 61–66 Lys-Ala-His-Gly-Lys are homologous. It is, however, surprising that these sections in the chains are shifted five amino-acid residues apart. While the sequence of the preceding peptide in this section of the β-chain is already known, the equivalent peptide from the α-chain has not been determined analytically. It would be expected that a restriction for five amino-acid residues of the α-chain occurs in that part of the chain. As reported in earlier communications[12,13], and as is evident from Fig. 3, the constitution of the last third of both peptide chains is not yet known unequivocally. Although the exact number of amino-residues of the β-chain is not yet definite, because of uncertainties in the analysis of both cysteine peptides, it is already possible to say with certainty that the β-chain is larger than its homologous α-chain and contains approximately eight more amino-acid residues, whereas up to now only homologous chains with the same number of residues have been described.

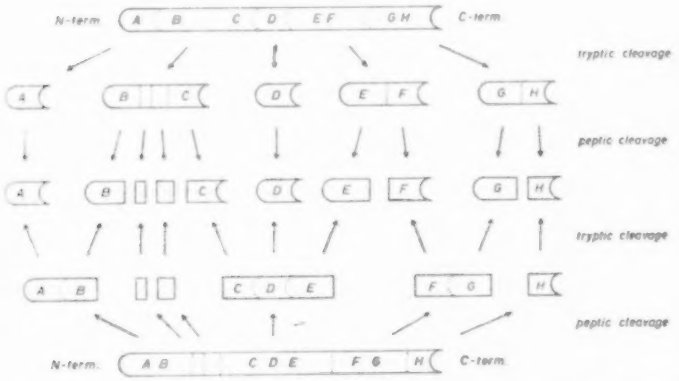

Fig. 2. Method for determining the position of the tryptic peptides within the chain

Theory

The structure of a protein reflects the structure of genetic material. A theory of protein structure is therefore equivalent to a theory of genetic substance. It must be assumed that originally a

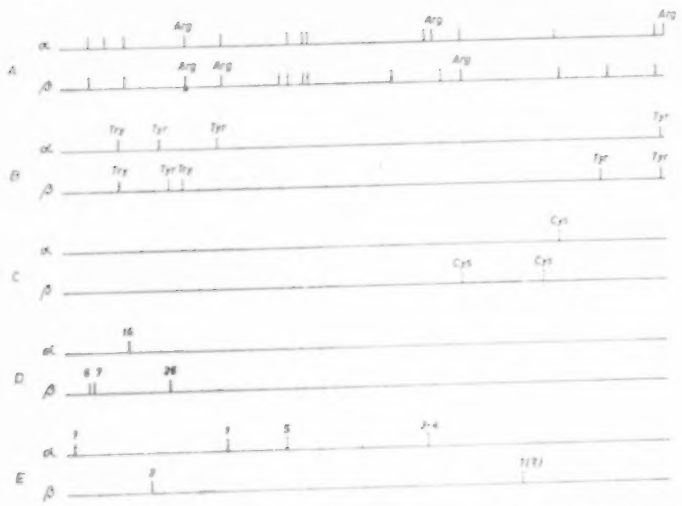

Fig. 4. Comparison of the peptide chains of the main component of normal adult human haemoglobin. (*A*) Comparison of the position of lysine or arginine residues; (*B*) position of the amino-acids tyrosine and tryptophan; (*C*) most probable position of the cysteine residues; (*D*) position of amino-acids in which the specific genetically determined replacement of amino-acids occurs in pathological haemoglobins (refs. 27–31); (*E*) position of blanks in the sequence; the broken lines mean that the exact position is not yet established; the numbers indicate the number of amino-acid residues missing in the chain and referred to as 'blanks'

simple haemoglobin existed; it consisted of a single peptide chain which corresponded to an equivalent complementary piece of genetic material. During evolution and further differentiation, a duplication of the genetic material must have occurred, which, however, from that point developed and differentiated independently, until it corresponded to the double peptide chains found at the present time. These changes must have occurred a long time ago, since the differences between the chains are rather extensive. Besides these changes, the genetic material must have been subjected to a restriction; this is probably the simplest interpretation of the sequence blanks in the protein structure of haemoglobin. In other words, the α- and β-chains behave like different species of peptide chains. Phylogenetically, however, the difference between the α- and β-chains is greater than the difference which has, for example, been found in the various kinds of insulin[25], where only an exchange of peptide chains of equal length has been established. In view of this finding, it seems to us that further essential insight into the structure of proteins has been achieved.

Sanger[25] was able to show—as indicated above—that proteins of various sorts differ by replacement of certain amino-acids. We believe that we have demonstrated experimentally, for the first time, a restriction at the molecular level. This finding can therefore only be explained if two complementary chains occur in haemoglobin, whereby one in a certain sense serves as a standard for comparison and vice versa. The question of the linear structure of a molecule appears to us to be of the greatest importance for an understanding of evolution on a molecular basis. These results provide fresh stimulus for a comparison of proteins of various species, and also of the investigation of proteins with several peptide chains. It remains to be seen whether findings in other proteins will extend the results presented here.

A year ago, a three-dimensional Fourier analysis of horse haemoglobin with a 5·5-Å. resolution was reported in *Nature*[26]. A resolution of 2·0 Å. appears now to be possible. The partial formula of human haemoglobin presented here already contains all the essential outlines of its primary structure. It is only necessary to complete about 110 sequences, which, however, offer no further methodological difficulties.

In order to give a more complete and clearer view of the position in this field of work, we have arranged several reference points in the structure of haemoglobin peptide chains opposite to each other in Fig. 4.

Further details of these results will be presented in *Hoppe-Seyler's Zeitschrift für physiologische Chemie*.

We wish to thank Prof. A. Butenandt, director of this Institute, for his generous support of this work. These investigations have been aided for the past several months by a grant from the Deutsche Forschungsgemeinschaft. We also wish to thank Miss B. Schrank, K. Haselhorst, R. Pagel and Mr. O. Ilg for assistance.

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POLLEN ANALYSIS IN UGANDA

By Dr. M. E. S. MORRISON
Makerere College, Kampala, Uganda

THE vegetations of the past thousands of years can be reconstructed accurately by isolating and identifying the pollens which are preserved with their diagnostic features intact in the anaerobic sediments of fen and lake. In Europe this work, known as pollen analysis, has established a succession of vegetation types which appeared since the retreat of the last ice sheet some 10,000 years ago, and active work delves into more remote eras. These vegetation types probably arose in response to the different climates which prevailed in the past; and although there are many factors which obscure a straight correlation between vegetation and climate it is entirely true to say that pollen analysis has provided the most accurate and consistent story of Europe's environmental past. The vast body of facts which has been gleaned may be appreciated very readily by browsing through Godwin's[1] recent book *The History of the British Flora*, which has the telling sub-title *A Factual Basis for Phytogeography*. All this has been accomplished by a few enthusiastic workers within the past thirty years. The question I now wish to consider is: Can pollen analysis give an equally informative record of the Quaternary history of East Africa?

This is the question which Hedberg[2] put into many minds when he indicated recently that pollen analysis might be successful on the lakes and fens of tropical East Africa. In Uganda it would certainly be very good to have new and independent evidence for the history of vegetation and climate in the Quaternary period, because it is certain that Uganda has suffered an over-emphasis of correlations based on climatic interpretations of important stratigraphic sites, such as those alongside the Kagera River. Wayland[3], who has travelled widely in Uganda, and was for many years the director of its Geological Survey, believes firmly that the Kageran stratigraphy supports an interpretation—perhaps not wholly—in terms of pluvial and inter-pluvial periods. Brooks[4] suggested that these might have been the tropical counterparts of the glacial and interglacial periods of the north temperate region. Wayland, however, stresses that the terms 'pluvial' and 'inter-pluvial' are unfortunate because in some minds they conjure up fantastic ideas of Noachian deluges separated by periods of extreme desiccation. Bishop[5] is an informed antagonist to the out-and-out climatic ideas, and it is instructive to compare his and Wayland's interpretation of the unquestionably important Kageran stratigraphy. Much of the difficulty and ambiguity in the evidence springs from the fact that beaches and terraces in East Africa cannot be straight away linked to climatic fluctuations, for changes in drainage and in lake-levels may have originated in tectonic movements, which have been extensive between the eastern and western rift valleys and around the Lake Victoria basin[6].

Part of the past year was spent in searching for suitable pollen-bearing deposits in Uganda, and, having had the good fortune to discover some excellent sites, I am sure that many of my colleagues will be interested in their whereabouts, and in the results from our first long pollen profile from this region.

Organic deposits, which have preserved pollen, are not common in Uganda because in the continuously warm climate the bacteria work very efficiently and all plant debris is rapidly mineralized. Thus, although there are vast swamps[7,8] of papyrus (*Cyperus papyrus*) and tall grass (*Miscanthidium violaceum*) all around the shores of the Lake and on the rivers, these are underlain usually by fine clays. These swamp clays, which are useless for pollen analysis, occur widely in the kingdom of Buganda, lying to the east and west of Kampala. The altitude of the region is about 4,000 ft.; the temperature ranges between 60° and 80° F.; the rainfall varies from 30 to more than 70 in. per annum, according to the locality; and the potential evaporation is a little more than 40 in. per annum. But at 6,000 ft. as near Kabale (Fig. 1) the temperature-range is 50–70° F., and the more sluggish bacterial industry allows peat to form and accumulate, and its depth is ultimately decided by drainage. The rainfall around Kabale may be about 40 in. a year and the annual potential evaporation about 30 in. In the Kashambya valley, near Kabale, Dr. Lind[7] found a maximum of a little more than 6 metres of peat, and in the Ishasha Valley—which is about the same altitude as the Kashambya—I have drilled through 14 metres in one place and reached the base, but through 18 metres in another place and not touched solid bottom. These, however, are possibly rapidly formed peats; but we find splendid compact peats and muds, which have formed probably slowly over many thousands of years, in the Rukiga Mountains, which are a short distance away, between Kabale and Kisoro.

Geologically speaking[9], the Rukiga Mountains consist of a 27-mile-wide belt of strike-ridges with intervening valleys—which are mature and very steep—descending often to a depth of 1,000 ft., and sometimes to 1,800 ft. This is the little Switzerland of Uganda, and it is much loved by all who know its hard-working, cheerful people, and its beautiful views of hilltops and island-studded lakes. As with most of Uganda, this countryside has been modified by changes of the Earth's crust, and here these movements have originated from the western rift valleys. But the lakes and fen-filled valleys, for the most part, owe their origin to drainage which has been impounded behind small volcanoes and lava flows. The now dormant and very lovely volcanoes, Muhavura, Mgahinga and Sabinio, are at the very south-west of the Rukiga Mountains, and they are part of the larger volcanic field known to geologists as the Bufumbira Bay. There are also small volcanic centres, such as Muko in the heart of the Rukiga Hills; the deposits around Muko are very interesting.

Muko is a tiny village from which a long, extremely narrow, and steep-walled valley runs into the north-west. This valley is neatly dammed by a cluster of small craters which rise to about 200 ft. behind the village. Drainage of the valley accumulated behind

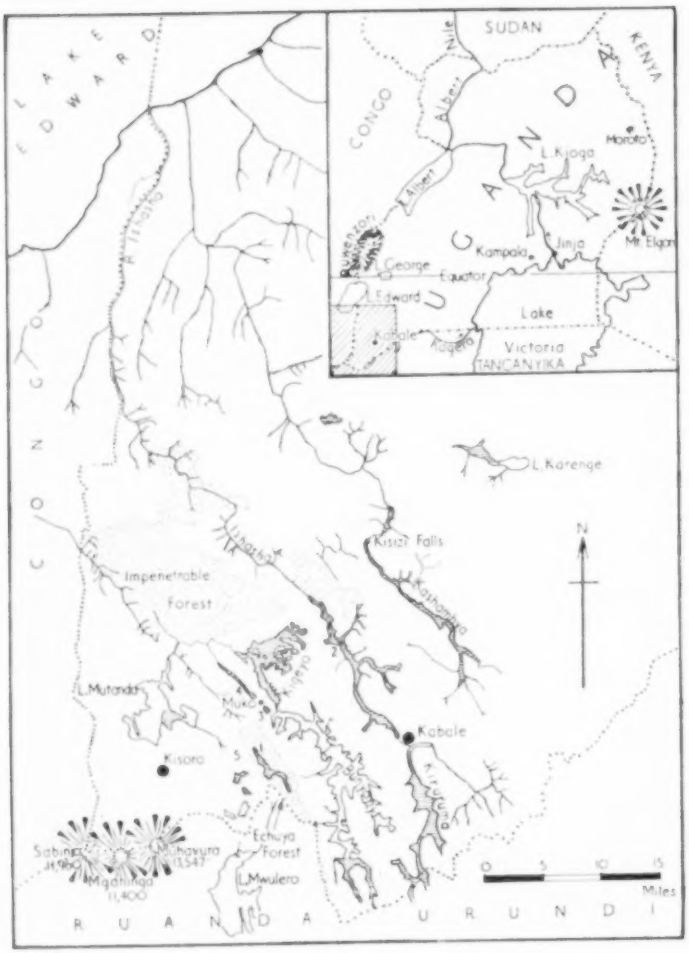

Fig. 1

this dam and a long lake formed, and this is now almost entirely filled in by lake muds and peats. In this valley, and just a short distance back from the volcanic bar, samples were collected through 20·5 metres of lake muds, and the base was not touched. The composition of the peat at that depth leads me to believe that there may be at least another 4·5 metres before the floor of the valley.

From Muko several sluggish lava streams made their way down the valley to the south-east so that finally they blocked the larger valley within which Lake Bunyonyi afterwards formed. Bunyonyi is an interesting lake with no indigenous fish, and this is remarkable because its overflow goes through Kigeyo fen and ultimately into Lake Mutanda, which has fish. But Bunyonyi waters are periodically deoxygenated. Now, part of the lava stream which halted at the north-west end of Lake Bunyonyi was diverted a little to one side by a rocky outcrop, and it impounded a smaller lake (site 3, Fig. 1) in a tributary valley. This lake has been completely infilled, and a drilling, believed to be near the centre of the deposit, gave 20 metres of lake muds, clay-muds and algal muds. The bottom, which was touched at this depth, was hard and presumably was a flooring of lava; the other dominant rock of the area is relatively soft Karagwe–Ankolean shale. Now, since the lake developed behind the lava flow and the lake muds rest on the lava, it is obvious that there are attractive opportunities here, and in the valley behind Muko (site 4), for correlating by pollen analysis and perhaps dating by radiocarbon the volcanic outbursts. Geologically, the lava flows should be relatively young because Lake Bunyonyi appears to have no high-level beaches, which means it has not yet had sufficient time to cut down the level of the outlet which flows over lava below Muko.

Other excellent deposits, and some of them similarly dammed behind lava flows, have been found on the Kisoro side of the Rukiga Mountains; one of these at a small village called Butongo (site 5) has been carefully sampled. Here a late stage of lake colonization has just occurred with a thick, floating mat of *Sphagnum* laced together with *Miscanthidium*. The drill penetrated very compact lake muds, lake clays and algal muds, this time to a depth of 20·5 metres. Near the base there was black ash in the mud, and volcanic pebbles.

The most elevated deposit we know of in the Rukiga Mountains is in Muchoya Valley (site 1); it is sometimes known as Elephant Valley. This valley is entirely enclosed by the Echuya forest reserve, which is of almost undiluted and dense bamboo (*Arundinaria alpina*). The valley has never been blocked by lava, but its drainage has been impeded by tilting, and for some time in the past there has been a long lake. The stratigraphy of the valley-filling was studied by drillings along a transect, and this proved a flat-bottomed valley, filled for the most part with lake muds. These are overlain by fen forest peat, and this in turn by a fen peat built up of tussocky sedges. The maximum depth of the deposit was 11 metres, and samples were collected at 2- and 5-cm. intervals, but with great difficulty in the lowest few metres because the muds were very firm and compact. It is from this valley that we now have the first long pollen profile from East Africa. I believe that this is an extremely important profile because of the position of this Muchoya deposit in the vegetational zones of the mountains. I worked on the theory, when choosing it, that a change of climate would have induced a movement of the altitudinally zoned vegetation of the Rukiga Mountains. Thus, there might be a record in the wind-borne pollen of a replacement of the bamboo by the succeeding zone of *Hagenia*, or by the underlying zone of Montane rain forest. Probably many readers are unfamiliar with these zones[10] of the East African

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mountains. There are three main belts: (1) Montane forest belt, 5,576–7,544 ft., 9,840–10,824 ft.; (2) Ericaceous belt, 8,504–11,152 ft., 11,480–13,448 ft.; (3) Alpine belt, 13,448 ft. upward. But the Rukiga Mountains with their peaks between 8,000 and 9,000 ft. are not high enough to harbour, to-day, the ericaceous and alpine belts, and indeed do not have even all the montane forest belt. This last-mentioned may have three zones, which reading from the base upward are: (1) montane rain forest zone; (2) bamboo zone; (3) *Hagenia* zone. The uppermost of these, the *Hagenia* zone, is absent to-day from the Rukiga range, and the bamboo consequently extends to the hilltops. The Impenetrable Forest, on slightly lower hills to the north-west of Muko, has only a few small areas of bamboo, and is dominated by rain-forest tree genera, including *Parinari* (Rosaceae), *Piptadenia* (Mimosaceae) and *Chrysophyllum* (Sapotaceae).

The entire pollen profile from Muchoya fen includes many genera of wind-borne pollen, and it would be confusing to reproduce it here where there is no space for an adequate introduction to the ecology of the plants involved. For simplicity, therefore, I have shown only two curves, *Hagenia* and *Stoebe*. *Hagenia*[11] is a rosaceous tree up to 50 ft. in height, with imparipinnate leaves and handsome panicles of flowers; the female reddish, the male white. *Stoebe*[12] belongs to the Compositae, and is a shrub up to 30 ft. in height, deceptively ericoid in appearance. According to Hedberg[12] it is "Co-dominant with *Philippia* spp. and *Erica* in forest or scrub on dry localities, sometimes scattered in grassland, from the (upper part of the) Montane forest belt, throughout the Ericaceous belt, and occasionally reaching into the lower part of the Alpine belt".

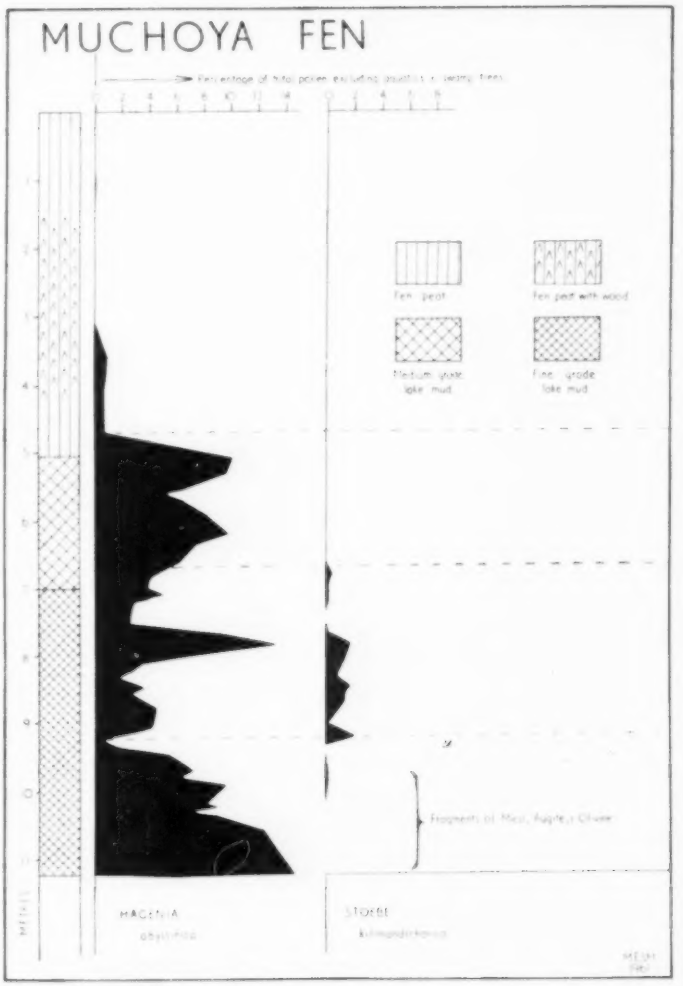

Fig. 2

Turning our attention now to the pollen profile (Fig. 2), we observe that, as the deposit began to accumulate, the surrounding hillsides were filled in with large amounts of *Hagenia*. Now this is very significant, because, as I have pointed out, *Hagenia* does not occur to-day on the Rukiga Mountains, except as occasional trees along the roadside and in clearings in the bamboo. From being initially high, the *Hagenia* percentages fall to a minimum close to 9 metres, and this could be regarded as completing the first zone of the profile. *Stoebe* was sparingly present in this first zone, but it becomes abruptly more prominent at the *Hagenia* minimum and its higher values persist to mark out, perhaps, a second zone in which, apart from a peculiar peak at 8 metres, *Hagenia* values are fairly low. At present we cannot explain these events because we know too little of the ecology of the plants. It is possible that this second period was one of greater cold, because *Stoebe* is more common in the ericaceous belt than in the montane forest belt. I believe, too, it is worth noting that *Stoebe* is not to-day known from the Rukiga or Ruwenzori Mountains, but it is recorded from western Congo, from Mts. Moroto and Elgon in Uganda, and from mountains in Kenya.

As *Stoebe* dwindles, the *Hagenia* recovers and reaches higher and sustained values which may mark out the third zone of the profile. This zone ends with the abrupt decrease of *Hagenia*, and I assume it was replaced entirely by bamboo, which has persisted to the present. Bamboo may, of course, have been intermingled with the *Hagenia* in the first three zones, but we have no evidence of this; and, in fact, its presence will not necessarily be recorded in the pollen. It is a strange fact that the bamboo on the Rukiga Mountains has never been found in flower, and the Africans of the area have no knowledge of its flowering at any time in the past. I think they are likely to have observed such an event because the plants die after flowering. I have heard

it said that in the Far East large tracts of bamboo forest flower at long time-intervals, and the flowering is regarded as a bad omen. The bamboo fruits are much desired by rats which invade the area and afterwards set about ravaging stores of grain, so that ultimately famine may result.

Within limits, bamboo can be inferred in the upper part of the Muchoya profile from other observations. The bamboo is always accompanied by some plants which may exist also in the Montane rain forest. Thus one finds *Afrocrania* (Cornaceae), *Dombeya* (Sterculiaceae), *Lachnopylis* (Loganiaceae), *Mimulopsis* (Acanthaceae) and *Ilex* (Aquifoliaceae)[11]. Where we find pollen of these plants, but not of rain forest genera such as *Parinari* (Rosaceae), *Piptadenia* (Mimosaceae) and *Chrysophyllum* (Sapotaceae), then we may tentatively infer the presence of bamboo forest, though perhaps some of the first-mentioned genera could occur also in *Hagenia* scrub. I must add that bamboo does flower in some parts of Africa, and in my type-collection there is pollen taken from plants on Mt. Elgon and from the Aberdares in Kenya. The pollen is very large, and this, with the distinct pore morphology, distinguishes it from many pollens of the wild grasses.

With only this pollen profile for evidence, and little knowledge of the ecology of *Hagenia*, *Stoebe* and *Arundinaria*, one tends to fall back on climatic change as a cause for the former dominance of *Hagenia* and its replacement by bamboo. But we must be careful not to leap to a climatic interpretation because we are unable to discuss other perhaps potent ecological factors. We should also learn a lesson from the evolution of thought about European pollen profiles. These, at first, were explained almost wholly in terms of climate, but the most recent discussion[12] seems to find little room for climate and brings forward prominently succession, competition, and human interference. Therefore, it is right that we should emphasize the possible importance of these other causes for the 'shape' of the Muchoya profile.

Human interference perhaps may be ignored, because it is believed that the movement of people into the upper, cool parts of the Rukiga Mountains has been recent. But a reasonable explanation, on the other hand, in terms of ecological succession, could be constructed. Consider that *Hagenia* might arise in the place of bamboo if this vanished because of fire, or as a natural consequence of its flowering. I raise the possibility of fire because of the fragments of mica, augite and olivine in the lower several metres. These fragments must have come from a volcanic eruption, and, of course, if much ash had fallen on the landscape then fires might indeed have swept the bamboo. Afterwards it might not have recovered, for, unless the fire had immediately followed a rare flowering, there would have been no bamboo fruits to have given a new generation. But it seems improbable that there was a fire, and there is no layer of ash in the stratigraphy; and indeed the fragments of rock I mention are very minute and few. Since at present these considerations do not lead us to anything promising, we are possibly justified in assuming that the replacement of *Hagenia* by pure bamboo was caused by a change of climate—perhaps an amelioration—some hundreds or thousands of years ago. Without radiocarbon assay there is no possibility of dating any part of the profile. Interpretation of the profile will be very much easier when we have further profiles from the Rukiga Mountains. I have now commenced work on the 20·5-metres deep profile from Butongo (site 5). This site is not now in the bamboo forest, but is in the cultivated zone only 600 ft. below the present lower limit of the bamboo.

I have said nothing of the deposits actually hidden beneath lakes such as Victoria and Bunyonyi. These deposits cannot be sampled with the Hiller drill, which was used for the other places I have mentioned. A special device is necessary to obtain deep-water samples, and Lake Bunyonyi is about 130 ft. deep. We hope to use an ingenious device created by Dr. F. J. H. Mackereth[14] at the Freshwater Biological Association's Laboratories at Windermere, England. It is powered by compressed air and obtains cores 6 metres in length, and it can work down to a depth of 250 metres of water. Because the diameter of the core is 1½ in. it should be possible to study pollen, plankton and chemistry. This should prove especially interesting in Lake Bunyonyi which, as I said earlier, is periodically deoxygenated and is without indigenous fish.

I hope this short account has indicated the richness and fascination of the field open to the pollen analyst in Uganda. I wish to thank the many friends from whose foresight and co-operation I have benefited. I am intensely grateful to Dr. Edna Lind, head of the Botany Department at Makerere College. Dr. Lind perceived the possibilities for pollen analysis in Uganda and arranged for me to be sponsored by the Nuffield Foundation and by Makerere College.

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OBITUARIES

Prof. T. R. Elliott, C.B.E., F.R.S.

T. R. Elliott was born in 1877, in County Durham, and went to Cambridge in 1896, where he took the Natural Sciences Tripos and later was elected to a number of already famous studentships. It was while he held these that Elliott carried out a series of researches in physiology which, in the words of Sir Henry Dale, "were of well-nigh incomparable brilliance and authority, for a worker so young in years and experience".

His interests lay in the effects of the autonomic nervous system, and his attention was caught early

by the resemblance between these effects and those of adrenaline. These researches led him, far in advance of his time, to propose the concept of the chemical transmission of nerve impulses, thereby anticipating by nearly a quarter of a century the flood of productive work in this field. His election to the Royal Society in 1913 was a well-merited recognition of his brilliance.

In 1906, Elliott resumed his medical studies and, four short years later, he was appointed physician to University College Hospital, London. There he became closely associated with Thomas Lewis. This was the turning-point. The traditional structure of education in medicine had long been giving cause for concern, and the appointment of a Royal Commission under Lord Haldane to report on university education in London was the occasion for its searching analysis. Among the proposals made was that recommending the creation of whole-time professorial posts in clinical subjects. But the First World War came and delayed its implementation, and Elliott was in France by September 1914. Then followed four years of intensive work in which Elliott became the projection into the battlefield of the medical knowledge and skills which Walter Fletcher, of the old Medical Research Committee, was brilliantly mobilizing at home. As Elliott himself admitted, it was here that he discovered his power for combining science and administration.

The War ended; attention returned to the Haldane Report and Elliott became, inevitably, one of the first whole-time professors of medicine in London. It was expected that this would herald a spate of researches in the clinical field comparable to those that distinguished his early days in physiology. That this did not happen was largely Elliott's conscious decision. He recognized that, if clinical research was to draw level with the experimental biological sciences, then his generation had to sacrifice their personal advancement to developing and organizing the new scientific medicine; and the state of medical progress in Britain to-day is the present memorial to him and his fellows. The advancement of knowledge was his criterion. From the earliest days he was associated with the Medical Research Committee, and he was the only man who has ever served three full terms as a scientific member of its successor, the Medical Research Council. As an indication of the respect in which his judgment was held, it may be mentioned that, young as he was and not a member of the Committee, his advice was asked on the appointment of the first secretary, and it was he who suggested Walter Morley Fletcher.

But in the notices that have appeared since Elliott's death there has been one note common to all—respect for him as a man. Many men have been intelligent, upright and courageous, but in addition Elliott possessed an almost disconcerting ability to detect bias and an indifference to credit that, but for his tolerance, would have made him forbidding. It is no wonder that he remained the trusted counsellor of men with great responsibilities, or that, in need, his was the aid that was sought.

H. P. Himsworth

Rev. J. E. Hull

With the death of the Rev. J. E. Hull in October 1960 at the advanced age of ninety-seven we have lost the last of the Rev. O. Pickard-Cambridge's pupils in the study of spiders.

After leaving St. Bede's College, Hull took a degree in mathematics in the University of Durham before returning to St. Bede's as vice-principal in 1890. Later, his work as a clergyman in various Northumberland parishes confined his natural history work mainly to that county.

He shared with Dr. A. R. Jackson and W. Falconer the chief credit for making known the spider fauna of northern England. He described two British spiders new to science, and six of his proposed new genera have survived. He also did extensive work on mites and edited a northern quarterly journal, *The Vasculum*. His last paper was published when he was ninety-two.

W. S. Bristowe

Dr. M. F. E. Nicolai

Dr. M. F. Emilie Nicolai, algologist and biophysicist, director of the Hydrobiological Institute at Hilversum, Holland, died suddenly at her home in Holland on March 13. There can be few people whose passing has brought sorrow to such a wide circle of devoted friends.

Dr. Nicolai was born at The Hague on June 27, 1900 where she received her early education. In 1918 she entered the University of Leyden as a student in biology and in the subsequent years she studied botany, zoology, mineralogy, geology, chemistry and physics. Her doctor's degree was awarded in 1929 on a thesis "On Changes in Permeability in the Root Cells of *Sinapis alba*". She remained associated with Leyden until 1942 first as assistant, and later head assistant, to Prof. J. M. Janse and then, from 1931 onwards, to Prof. L. G. M. Baas Becking. During this time her published work lay in the fields of physiology and ecology, though one of her papers (on chlorophyll multifilms, with Dr. C. Weurman) already indicated her interest in the application of physical principles and methods in biology. Her first serious work in the fields both of algology and in biophysics came during this period when, in 1937, she visited the Eidgenossische Technische Hochschule, Zurich, to work under Prof. Dr. A. Frey-Wyssling on the cell wall structure of *Chaetomorpha*. It was no mere coincidence that at this same time my own interests had turned toward the related genus *Cladophora*, causing us afterwards to work closely together for so many years. In 1942 Dr. Nicolai transferred to the Fibre Research Institute, Delft, under Dr. J. R. H. van Nouhouys, and in 1946 became head of the Biological Department. Though, so far as I know, she never worked with him, she was deeply impressed by Prof. G. van Iterson, jun., and it was largely through his influence that in 1947 she came to England first as my research assistant and then as lecturer at Leeds. This was the beginning of a fruitful collaboration on wall structure in the algae lasting almost ten years, opening up a new field and laying down a foundation of work for many years still to come. It was during this period that she made her name as an algologist. Our collaboration terminated when her loyalty to her country led her in 1957 to accept the position of director of the newly founded Hydrobiological Institute in Holland, though she frequently returned to Leeds.

Dr. Nicolai was a botanist of wide experience and a first-class investigator, and for this alone her death would be a serious loss. But she was much else beside. Warm-hearted and generous and with friendliness overflowing to all, 'Nick's' intuitive

understanding of, and sympathy with, the problems of her associates never allowed her to speak ill of anyone. Though small in stature, she was always dignified. To many of us her calm unruffled manner was a source of constant strength, and we are all the better for having known her. Few women scientists can have been so well beloved as was 'Nick' by people in so many walks of life. Wherever she went, in Europe or farther afield, in shops or in the rooms of learned societies, she was soon surrounded by her friends.

R. D. PRESTON

NEWS and VIEWS

Royal Society : Foreign Members

THE following have been elected foreign members of the Royal Society: Prof. Olaf Holtedahl, professor emeritus of geology in the University of Oslo and member of the Norwegian Academy of Sciences, Oslo, distinguished for his outstanding contributions to geology, particularly of Norway and the arctic regions; Prof. Solomon Lefschetz, Henry B. Fine professor emeritus of mathematics in Princeton University, Princeton, distinguished for his work in the fields of algebraic geometry and topology; Prof. Elmer Verner McCollum, professor emeritus of biochemistry in Johns Hopkins University, Baltimore, distinguished for his services to the science of nutrition; Academician Aleksandr Nikolaevich Nesmeyanov, president of the Academy of Sciences of the U.S.S.R., Moscow, distinguished for his contributions to organic chemistry, particularly on organo-metallic compounds.

Civil Engineering at University College, London : Prof. A. H. Chilver

DR. A. H. CHILVER, who has been appointed to the Chadwick chair of civil engineering in University College, London, in succession to Emeritus Prof. H. J. Collins, was born in 1926. He was educated at Southend-on-Sea High School for Boys and at the University of Bristol, graduating in 1947. He was awarded the Albert Fry Prize in 1947. After leaving Bristol, Dr. Chilver worked for a year with London Midland Region of British Railways on structural steelwork design. He then returned to the Civil Engineering Department, University of Bristol, in 1948, as a research student. He was appointed assistant lecturer in civil engineering in the University in 1950 and eventually lecturer in 1952. He left Bristol in October 1954 on his appointment as a University demonstrator in the Engineering Department, Cambridge. He was promoted to a University lectureship in 1956 and was elected into a fellowship at Corpus Christi College in January 1958. Dr. Chilver's main fields of research are structural stability and related problems; stability of thin-walled metal structures, stability of complete frames, buckling of shells; structural safety; loads on engineering structures and strength of structural materials. His publications consist of various papers on structural stability published in engineering journals, an elementary text-book on theory of structures written in collaboration with R. J. Ashby and another on strength of materials written in collaboration with J. Case.

Chair of Mechanics at Cambridge : Prof. D. C. Johnson

PROF. D. C. JOHNSON, professor of mechanical engineering in the University of Leeds, has been appointed to a chair of mechanics in the University of Cambridge. Prof. Johnson was born in 1915. He was educated at Mill Hill School and was a Minor Scholar at King's College, Cambridge, during 1934–37. He was placed in the first class in the Mechanical Sciences Tripos in 1937, gaining distinction in heat and heat engines. After leaving Cambridge, Johnson worked during 1937–47 for Rolls-Royce, Ltd., Derby. He returned to Cambridge in 1947 as a University demonstrator and was appointed a University lecturer in 1948. He was appointed secretary to the Faculty Board of Engineering in the University and elected into a fellowship at Trinity Hall in 1954, resigning in 1955 to take up the chair of mechanical engineering at Leeds University. Prof. Johnson's main field of research is vibrations, on which subject he has lectured widely and contributed several papers. His latest publication, "The Mechanics of Vibration", was written in collaboration with Prof. R. E. D. Bishop and published by the Cambridge University Press in 1960.

Nature Conservancy Appointments

THE Nature Conservancy has appointed Prof. J. B. Cragg as director from June 1, 1961, of the Merlewood Research Station, Grange-over-Sands, and Dr. K. Mellanby as director from October 1, 1961, of the new Monks' Wood Experimental Station, to be built on a recently acquired site near Huntingdon.

Prof. J. B. Cragg

PROF. CRAGG has had some twenty-five years experience of university work. In addition to his academic duties he has served on a range of major official committees and has visited Israel, West Africa and the Antarctic. He was appointed reader in zoology in the University of Durham (Durham Colleges) in 1946 and then professor in 1950, during which period he has written extensively on problems of conservation and ecology. Prof. Cragg is president of the British Ecological Society and chairman of the Agricultural Research Council's Pest Infestation Research Board. He has also played an active part in the affairs of the Institute of Biology as member of Council, editor and vice-president. The main research at Merlewood, which the Nature Conservancy set up in 1952, concerns the study of woodland ecology, with an emphasis on nutrient cycles. Moor House Field Station, on the Westmorland Pennines near Alston, Cumberland, will also be directed by Prof. Cragg.

Dr. K. Mellanby, C.B.E.

DR. MELLANBY is one of the few senior entomologists with experience in both medical and agricultural entomology. His main interest has been concerned with the reactions of insects to temperature and humidity, a subject on which he has written many papers. He has carried out much research work in Britain and other countries (mainly tropical countries). In 1955, he became head of the Department of Entomology of Rothamsted Experimental Station.

He is president of the Association for the Study of Animal Behaviour and vice-president of the Royal Entomological Society. The establishment of the Nature Conservancy's new Experimental Station at Monks' Wood (adjoining the National Nature Reserve) will provide Dr. Mellanby with a challenge and an opportunity for which his broad experience is especially relevant. When building is completed in 1962, the Station will house three teams studying the effects of toxic chemicals on wild life, ecological management of native woodlands and scientific problems of conservation. The Station will also form a base for field studies of the diploma course on conservation of University College, London, and for other university and related activities. The Station is already functioning in embryo in temporary premises, and it is hoped that it will be fully operative by 1963.

The James Craig Watson Medal : Prof. O. H. L. Heckmann

THE James Craig Watson Medal of the U.S. National Academy of Sciences has been awarded to Prof. Otto Hermann Leopold Heckmann in recognition of his noteworthy contributions to astronomy. The Medal, established in 1874 by the bequest of Dr. Watson to recognize astronomical discoveries or work "worthy of special reward", was presented to Dr. Heckmann at the annual meeting of the Academy on April 24. As professor of astronomy in the University of Hamburg and director of the Hamburg Observatory at Bergedorf, West Germany's leading observatory, Dr. Heckmann is widely known for his work in astrometrics. Under the direction of his predecessor, R. Schorr, the Hamburg Observatory undertook about 1930 the enormous task of photographing and measuring the positions of the stars of the northern hemisphere. This work, known as the *AGK2*, was published in fifteen volumes. Dr. Heckmann initiated a repetition of it, enlisting the co-operation of a group of observatories in Canada, England, France, West Germany, East Germany, the U.S.S.R., and the U.S. Naval Observatory in Washington, to join in a concerted effort to derive, by new observations, the proper motions of 180,000 stars. Completion of the new catalogue, *AGK3*, is expected in about three years. Dr. Heckmann is internationally regarded as an expert in the field of relativity and cosmology. His work in this field includes not only contributions to the theory of cosmology but also critical assessments of the observational and experimental basis of cosmological theories.

The CIBA Fellowship Trust : Awards

THE following were recently awarded CIBA fellowships: Mr. R. F. C. Claridge (University of Auckland and University of Cambridge), for post-doctoral work at the University of Cologne (radiochemistry); Dr. J. S. Littler (University of Oxford), for post-doctoral work at the Federal Technical Institute, Zurich (chemistry); Mr. H. Stern (University of Oxford), for post-doctoral study at the University of Brussels (theoretical physics); Mr. F. I. B. Williams (McGill University and University of Oxford), for post-doctoral work at the University of Liège (solid-state physics). Fellowships previously awarded to the following were renewed for a further year: Dr. V. P. Arya, at present working at the University of Stockholm (natural-products chemistry); Dr. W. D. Hamilton, at present working at the University of Uppsala (nuclear physics); Dr. R. Grinter, at present working at the Federal Technical Institute, Zurich (physical organic chemistry); Dr. B. L. Mordike, at present working at the University of Göttingen (physical metallurgy).

Scientific Development and the Budget

IN his Budget speech on April 17, the Chancellor of the Exchequer, Mr. Selwyn Lloyd, expressed the view that productivity in Britain is being held down by shortages of skilled labour and that he is not satisfied that both sides of industry are invariably tackling this problem with sufficient energy. There are too few scientists and technologists. There are features in the tax system which make for inadequate rewards for initiative and enterprise. Some industries are insufficiently accustomed to competition and insufficiently aware of the need for technical improvement if they are to hold their own with their overseas competitors. Labour relations, standards of management and techniques of selling are sometimes below what is needed to-day, and certain industries are still, in his view, handicapped by restrictive practices which are completely out of date.

These comments were welcomed by Mr. H. Wilson, who wished to see them matched by action in scientific education and also measures to encourage scientific research in industry. He attributed the loss of young scientists and technologists to America to the poor prospects of promotion and inadequate salaries offered by many industries in Britain, and wished to see taxation on the middle ranges of scientists and executives reduced. The over-riding priority is to encourage science and technology. The total expenditure on scientific research, Mr. Wilson remarked, is £478 million a year, of which £370 million comes from public funds, while 52 per cent of the national expenditure on research and development goes on defence. Calling for a crash programme to train more scientists and engineers and a new policy for deploying them, Mr. Wilson urged even more a new and determined drive to apply science in industry. He suggested a wider use of the National Research Development Corporation and an expansion by 20 per cent of the 15,000 scientists at present employed on civil research and development.

The President of the Board of Trade, Mr. R. Maudling, agreed that we need much more research and development in British industry and also a rapidly expanding programme, as we now have, of scientific and technical education. Defence requirements, however, still limit the transfer of scientists and technologists from defence research to civil research. Mr. H. Nicholls thought that the Chancellor's surtax proposals would play some part in keeping in Britain the 2,000 scientists now leaving the country every year to work in competitor countries; the net loss, he pointed out, is about £1,000. Mr. D. Ginsberg, however, complained that the Budget did nothing to assist scientific research.

The Colonial Development Corporation

IN a statement in the House of Commons on April 27, the Secretary of State for the Colonies, Mr. Iain Macleod, said that to ease the financial position of the Colonial Development Corporation, the Government had decided to release the Corporation from the obligation to meet the liability of accumulated unpaid interest on long-term Exchequer advances, now amounting to about £11 million, when they

become due; the sum is to be placed in a special account in a way similar to that proposed by the Sinclair Committee, where interest will not be payable. The Corporation's debt of about £9 million, arising from projects abandoned by the Corporation, would also be placed in this account. Towards these two liabilities the Corporation would pay to the Exchequer 60 per cent of its net annual profits in excess of £250,000. The Government proposed to review these arrangements in three years time in the light of experience gained.

In future loan transactions, the period over which repayments to the Exchequer would be made would conform generally to that of the capital repayments which the Corporation would be receiving from third parties. For investments in shares, the Corporation would generally draw long-term advances for a 40-year period, and for this type of investment only the Corporation would not be required to service the Exchequer advances during the first seven years. Mr. Macleod said he was satisfied that these arrangements would be of real assistance to the Corporation and that they largely followed the recommendations of the Sinclair Committee. The Government had been unable to accept the recommendation that part of the advances should be converted to an equity share-holding in the Corporation, as this would have amounted to a subsidy over which there would not be full Government or Parliamentary control. In reply to questions, Mr. Macleod said that while the Corporation could bring to fruition projects it may have started in newly independent countries, its main effort should be made in starting new projects in the Colonies where the need was very great.

A Radio Telescope for the Department of Scientific and Industrial Research

A FULLY steerable radio telescope is to be built at a site near Crowthorne, Berkshire, by the Ministry of Works for the Radio Research Station of the Department of Scientific and Industrial Research. It is expected to be completed and in operation towards the end of 1963 at an estimated overall cost of £250,000, including buildings, equipment and site services. The instrument, which will have a parabolic aerial about 80 ft. in diameter, will have high accuracy and a faster tracking speed than the 250-ft. radio telescope at Jodrell Bank, an essential requirement for following Earth satellites and determining orbital data. It will be used to receive weak signals from distant space vehicles transmitting at ultra-high frequencies. In the field of radio astronomy, an application of the telescope will be a study of radio noise from the Sun, including sudden increases in radio emission which are related to disruption in short-wave communications. Also of interest is the radio noise from planets. The telescope will be valuable in extending investigations of the properties of the upper and lower atmospheres which are important in both terrestrial and space communications. This feature will assume even greater significance in the next few years, when satellites for communications, as well as for research purposes, are likely to come into use. In considering this project, the Council for Scientific and Industrial Research was advised by the following sub-committee: Sir Bernard Lovell (University of Manchester), Prof. Martin Ryle (University of Cambridge) and Dr. J. S. Hey (Royal Radar Establishment, Malvern).

Committee on Hydrological Research

In reply to a question in the House of Commons on April 18 asking for the creation of an organization to conduct basic research into the conservation and utilization of water supplies in Britain, Mr. D. Freeth, the Parliamentary Secretary for Science, said that the Department of Scientific and Industrial Research has set up a Committee on Hydrological Research, under the chairmanship of Dr. B. K. Blount: "to survey and assess current research relevant to water conservation in the United Kingdom; to identify needs for further research; to allocate priorities and to determine where research should be done and to co-ordinate the work as necessary". The Committee has already held its first meeting and the Ministries of Agriculture and Local Government, as well as other bodies, are co-operating fully.

The membership of the Committee is as follows: Dr. B. K. Blount (*chairman*), Department of Scientific and Industrial Research; Dr. E. C. Childs (Agricultural Research Council); Dr. H. L. Penman (Agricultural Research Council); Mr. E. A. C. Johnson (Ministry of Agriculture, Fisheries and Food); Mr. J. K. Wilson (Department of Agriculture for Scotland); J. E. Munro (Department of Health for Scotland); Mr. R. F. Wood (Forestry Commission Research Station); Mr. C. H. Spens (Ministry of Housing and Local Government); Mr. A. C. Boulton (Surface Water Survey, Ministry of Housing and Local Government); Mr. P. J. Meede (Meteorological Office); Dr. E. B. Worthington (Nature Conservancy); Prof. M. V. Laurie (Department of Forestry, University of Oxford); Mr. P. O. Wolf (Department of Civil Engineering, Imperial College, University of London); Mr. N. A. F. Pountree (Institution of Water Engineers); Mr. M. Nixon (River Boards Association); Dr. R. C. Allen (Water Research Association); Dr. S. Buchan (Geological Survey and Museum); Mr. F. H. Allen (Hydraulics Research Station); Dr. B. A. Southgate (Water Pollution Research Laboratory).

Malaria Eradication Campaign

In replying on an adjournment debate on the United Kingdom's contribution to the malaria eradication campaign on April 26, the Parliamentary Secretary to the Ministry of Health, Miss E. Pitt, said that the United Kingdom contributes already in four ways: through the regular budget of the World Health Organization; through the United Nations International Children's Emergency Fund; through the United Nations Technical Assistance Fund; and through the grants under the Colonial Development and Welfare Acts, the total expenditure under which for the purpose during the past twelve years was £760,000. In 1961 the contribution from the Malaria Eradication Special Account was about one-third of all that expended by the World Health Organization on malaria eradication, and amounted to 5·7 million dollars. The regular budget contributed 714,000 dollars, and the extended programme of technical assistance 639,000 dollars. The Special Malaria Fund of the Pan-American Health Organization contributed 3 million dollars and the United Nations International Children's Emergency Fund 8 million dollars, making a total of nearly 19 million dollars.

The Malaria Eradication Special Account was established in 1955 on the initiative of about 25 countries, but at the start the major Powers were opposed to the financing of such a scheme by soliciting

voluntary contributions from Governments, and it was not until 1957 that the United States changed its policy and contributed 5 million dollars to the Account. The British Government maintained the view that such an eradication campaign should be financed through the regular budget of the World Health Organization (to which the United Kingdom contributes 7 per cent), and at the General Assembly of the Organization in New Delhi in February the United Kingdom supported a scheme which would put any shortage in voluntary contributions immediately on the regular budget. The administrative and operational costs of more than 600,000 dollars had already fallen on the regular budget in 1961; an additional 2 million dollars would fall on it for 1962, double this for 1963; and the whole 6 million dollars in 1964, an increase of more than 20 per cent in the 1962 budget of 23·6 million dollars. This would involve further contributions from the United Kingdom of 140,000 dollars in 1962, 280,000 dollars in 1963 and 420,000 dollars in 1964. Under the scheme adopted, which gives credits to the member countries carrying out malaria eradication campaigns and have low *per capita* incomes, a group of about 30 countries with relatively large *per capita* incomes will share the burden which in the past was borne by a few volunteers but mainly by the United States, which contributed about 90 per cent. Miss Pitt said that in the future the Director-General of the World Health Organization would be able to plan more effectively, since he could rely on the resources of his regular budget, and she also emphasized the substantial contribution from Britain on the technical side in research and training facilities.

Public Health Nursing

The nursing profession throughout the world is faced with a severe shortage of recruits to its ranks. In the developed countries an increased burden is being placed on its shoulders by the growing complexity of medical services, treatment and equipment; the demand for nurses is rising at a time when the supply is falling off as a result of the availability elsewhere of better-paid jobs in easier working conditions. In the less-developed countries the demand for nurses is enormous; but the supply is restricted by unwillingness to allow women to become nurses, by the low status of nursing, and, above all, by the absence of the money to pay them. This crisis in the nursing profession has led to a re-appraisal of the functions of nurses and to various attempts to use auxiliary workers for the less-essential tasks of nursing, thus freeing nurses for the more-essential. A volume in the series of *Public Health Papers* by the World Health Organization contains a collection of papers by nursing and other experts from all parts of the world, who discuss the training and functions of public health nurses, the basic curriculum and the changes that the new situation is bringing about and should bring about in it, the importance of team work, the value of knowledge of administration, the role of the auxiliary worker, and the fresh approach now required of public health nurses (No. 4 : *Aspects of Public Health Nursing*. Pp. 185. 5 Swiss francs; 8*s*. 6*d*.; 1.75 dollars; by various authors. (Geneva: World Health Organization; London: H.M.S.O.) 1961). There are several contributions describing how countries—such as Brazil, France and the U.S.S.R.—have dealt with the problem of the auxiliary worker. A final paper discusses the difficulties met by international nurses working in other countries with strange cultures, different standards and attitudes.

Rural Research in C.S.I.R.O.

Among the many periodicals that nowadays come to our libraries, those of the Commonwealth Scientific and Industrial Research Organization of Australia have for long maintained a high value, and *Rural Research in C.S.I.R.O.* has for some years now kept agriculturalists well informed about the progress of agricultural research in Australia. The issue for December 1960 (No. 34, obtainable from the Agricultural Liaison Section of the Commonwealth Scientific and Industrial Research Organization, 314 Albert St., East Melbourne, C.2, Victoria) discusses the experimental work being carried out in Queensland on the rearing of cattle in a tropical environment, and the characteristics of the coats of the cattle in relation to this. Other articles deal with: research on the wool of sheep; sheep fluorosis; improved cobalt treatment of sheep; the use of the electron microscope in agricultural research (illustrated by striking photographs); soils and sulphur deficiency in soils; and new techniques which can extend the storage life of apples.

Bering Strait Dam

P. M. Borisov has outlined a project, in the October (1959) issue of *Literaturnaya Gazeta*, of a 90 km. long dam across the Bering Strait equipped with powerful pumps pumping cold Arctic Ocean water into the Pacific Ocean at the rate of 500 km.^{3} in 24 hours. Such a project, according to Borisov, would increase the flow of warm Atlantic Ocean water into the Arctic Ocean and change the climate of the Arctic regions. This project is criticized by D. A. Drogaitzev (*Priroda*, 6, 35; 1960), who, on the basis of detailed calculations, argues that such a project would displace the locus of Atlantic Ocean cyclones to the region of the Barentz Sea. Such a displacement would certainly change the climate of Northern Europe and Western Siberia, but this change will produce colder winters and hotter summers and will lead to the displacement of the desert belt from the region of North Africa and Central Asia to the north of Europe. At the same time the northern Pacific region will also undergo a climatic deterioration.

The Manchester Museum

In the annual report of the Manchester Museum for 1959–60, special mention is naturally made of three additions to the exhibition space. The special Japanese gallery to house the Lloyd collections has been completed, a coin room has been provided, and certain re-allocations with the University have made possible botanical offices and laboratories and the re-organization of the great herbarium. Two outstanding purchases were made during the year—two Celtic gold bracelets dug up in 1829 at Malpas in Cheshire and an Iron Age gold necklace found at Burnley in 1801. By the aid of various funds and a subscription list it was possible to purchase these three objects. A bequest of great importance was the Leslie Armstrong collection excavated from Pin Hole Cave, Derbyshire. It comprises about 14,500 bones, bone flakes, antlers and teeth. The report closes with an impressive list of publications by the staff.

The Birmingham Museum of Science and Industry

Birmingham City Council has approved the rebuilding of the Museum of Science and Industry,

Shortage of space for display and storage has prompted the Council to rebuild on the present site. Some of the very old buildings are structurally unsound, and would be most uneconomical to maintain in good repair. They will be demolished and replaced by a new building which will incorporate any suitable existing buildings. The scheme for rebuilding includes a new Locomotive Hall, an administrative block and an Engineering Hall. The scheme will be carried out in three phases over a period of several years. The total cost including professional fees will be in the region of £655,000.

Meteorites in the U.S.S.R.

In the first quarter of the last century, certain curiously shaped hollows were discovered on the land surface of the Island of Saremа in Estonia, but it was only in 1927 that I. A. Reinwald produced the correct interpretation of their origin. As reported by E. L. Krynov (*Priroda*, 7, 55; 1960) these hollows represent meteorite craters. They were studied in great detail by Reinwald and after his death in 1945 by A. O. Aaloэ, who carried out a systematic excavation of these craters and collected a large amount of fragments and dust belonging to iron meteorites. The disposition of the seven craters of the Kaalijarvi region suggests that, as in the case of the craters of Henbury in Australia, the Estonian craters are situated within an elliptical area of meteorite dispersion produced by a fall of meteorites which moved along a line stretching from south-south-west to north-north-east.

Reports of two meteorite falls in the U.S.S.R. have been forthcoming during the past year. According to M. A. Kashkai *et al.* (*Priroda*, 9, 109; 1960) an iron meteorite fell in Yardymly region, S.W. of Baku, Azerbaijan, at 8.5 a.m. November 24, 1959. This meteorite apparently broke into fragments before its fall as five distinct falls were registered. The collected fragments vary in weight from 360 gm. to 127 kgm. Calculations show that before fragmentation the meteorite was moving from the S.W. to the N.E. V. A. Yarmoluyk reports (*Priroda*, 11, 100; 1960) that a number of eyewitnesses observed a flight of a bolid accompanied by a flash and sound effect at 17h. 30m. local time on December 22, 1959, near the settlement Nurki, Dzhudzhur Range, fringing the Okhotsk Sea coast. It is presumed that these effects were caused by a meteorite fall, but no fragments of such have as yet been found in this region.

Artificial Melting of the Arctic Ice

A considerable handicap to navigation in the Arctic Ocean is presented by the delay of melting of ice in bays and river estuaries as compared with that in the open ocean. As described by I. S. Peschansky (*Priroda*, 7, 49; 1960), a most successful acceleration of the process of melting of ice has been achieved by dusting the surface of the ice with various dark-coloured materials along certain definite navigation lines. This allows a greater play of solar energy and the formation of 'radiation' channels a month and a half before the normal melting period of the ice.

Flora of the Rugby District

A good example of the way an educational institution and the neighbouring community can work together is provided by a publication describing the flora of Rugby and its environs. It has been prepared by a former scholar, D. E. Allen, with records supplied by boys of the school and members of the town. To the original *Flora*, which was first published in 1957, has now been added a supplement providing details of recent discoveries (Rugby School Natural History Society. A First Supplement to *The Flora of the Rugby District*. Pp. 4. By D. E. Allen. (Rugby: George Over, Ltd.) 1s.).

The Royal Irish Academy

At a meeting of the Royal Irish Academy in Dublin on March 16, Prof. John L. Synge, director of the School of Theoretical Physics in the Dublin Institute for Advanced Studies, was elected president. Prof. J. Doyle, Prof. J. J. Tierney, Prof. B. Ó. Cuív and Prof. F. E. Hackett were re-elected as secretary, secretary for polite literature and antiquities, secretary for Irish studies, and treasurer respectively. On the retirement of Dr. A. Farrington, who had been assistant secretary since 1928, Mr. Liam de Paor was elected executive secretary. The following were elected honorary members: in the Section of Science, Sir Harold Jeffreys, Cambridge, Edgar Lederer, Gif-sur-Yvette, and Lamoraal Ulbo de Sitter, Leyden; in the Section of Polite Literature and Antiquities, Roman Jakobson, Harvard, and Jerzy Kuryłowicz, Cracow. Mr. J. C. Beckett, Dr. J. G. Belton, Dr. J. W. Harman, Mr. J. P. Haughton, Dr. N. A. Porter, Dr. Yasushi Takahashi and Mr. F. G. A. Winder were elected members of the Academy.

The Royal Institution

At the annual meeting of the Royal Institution, held on May 1, the following officers were elected for the year 1961–62: *President*, Lord Brabazon of Tara; *Treasurer*, Mr. W. E. Schall; *Secretary*, Brigadier H. E. Hopthrow; *Managers*, Mr. F. G. Brown, Sir Harold Roxbee Cox, Mr. E. R. Davies, Prof. Alexander Haddow, Mrs. H. K. Hawkes, Dr. R. Holroyd, Miss E. Henrietta Jebens, Mr. L. B. W. Jolley, Prof. L. A. Jordan, Sir Ben Lockspeiser, Dame Kathleen Lonsdale, Dr. H. Lowery, Mr. W. R. Stevens, Wing-Commander H. F. Tiarks and Prof. W. D. Wright; *Visitors*, Mr. A. D. Baynes-Cope, Mr. A. D. R. Caroe, Mr. Norman Clarke, Miss F. M. Eastwood, Mr. A. H. Ewen, Dr. D. H. Follett, Mr. G. J. Gollin, Mr. N. P. W. Moore, Dr. A. A. Moss, Mr. J. D. Peattie, Mr. Frank Poperwell, Mr. F. Y. Poynton, Dr. H. R. Rishworth, Miss D. Sidebottom and Mr. H. Stanesby.

The Geological Society of London

The following were elected officers and council of the Geological Society of London at the annual general meeting held at Burlington House, Piccadilly, on April 26: *President*, Prof. S. E. Hollingworth, Yates Goldsmid professor of geology in the University of London; *Vice-presidents*, Prof. T. Neville George, professor of geology in the University of Glasgow; Dr. D. R. Grantham; Sir William Pugh, emeritus professor of geology in the University of Manchester, and lately director of H.M. Geological Survey; Dr. C. J. Stubblefield, director of H.M. Geological Survey; *Secretaries*, Mr. J. M. Edmonds, curator of Geological Collections, University Museum, Oxford; Dr. P. A. Sabine, principal geologist, H.M. Geological Survey. *Foreign secretary*, Prof. O. T. Jones, emeritus professor of geology in the University of Cambridge. *Treasurer*, Mr. P. Evans. *Ordinary members of*

council, Prof. J. G. C. Anderson (Cardiff), Dr. H. W. Ball (British Museum, Natural History), Prof. K. C. Dunham (Durham), Dr. R. G. S. Hudson (Dublin), Prof. B. C. King (Bedford College, London), Dr. Dorothy Rayner (Leeds), Prof. R. M. Shackleton (Liverpool), Prof. J. Sutton (Imperial College of Science and Technology, London), Prof. P. C. Sylvester-Bradley (Leicester). The following were elected members of the Society: Mr. M. Black, lecturer in geology, University of Cambridge; Mr. P. T. Cox, managing director, B. P. Exploration Co., Ltd.; Mr. D. Curry; Dr. K. A. Davies, deputy director, Overseas Geological Survey; Dr. Vernon Wilson, district geologist, H.M. Geological Survey.

The Franco-British Pharmaceutical Commission

THE Franco-British Pharmaceutical Commission was appointed in January 1950 by the Councils of the Pharmaceutical Society of Great Britain and of the Ordre National des Pharmaciens de France to promote co-operation in the field of pharmacy. The formation of the Commission was inspired by the Cultural Convention held by the Governments of France and Great Britain in 1948 at which the hope was raised that " . . . in each country the fullest possible knowledge and understanding of the intellectual, artistic, scientific, technical and educational activities and of the history and ways of life of the other" should be promoted. In the spring of each year since 1951 a team of French lecturers has visited towns in Great Britain, and a British team has gone to France. More recently, British experts have visited France (1960 Lille; 1961 Lyons) to study aspects of the practice of pharmacy there. Three British pharmacists have done research work at the University of Paris, and one is going to Bordeaux during 1961/62. Through the two Societies, the Commission is able to obtain information on most pharmaceutical subjects and to facilitate the exchange of scientific material, for example, specimens of drugs or medicines, between interested parties in the two countries. Week-end congresses, well attended by both French and British pharmacists from all parts of the two countries, have been held in the spring, alternately in France and Great Britain. The ninth Congress, which will be attended by about 100 French and 100 British, is to be held in Jersey during May 12–15, 1961. The secretary of the British Section of the Commission is Sir Hugh Linstead. Further information can be obtained from the Pharmaceutical Society of Great Britain, 17 Bloomsbury Square, London, W.C.1.

Announcements

PROF. JOHN STANLEY GRIFFITH of the Department of Chemistry, University of Pennsylvania, has been awarded the Faraday Society's Marlow Medal, for his work on ions of the transition metals.

DR. MAX F. PERUTZ, director of the Medical Research Council Unit for Molecular Biology, Cambridge, delivered the 1961 Chaim Weizmann Memorial Lecture at the Weizmann Institute of Science, Rehovoth, on April 18, when he was made an Honorary Fellow of the Institute for "his major contribution to the science of X-ray Crystallography applied to macromolecules and for his distinguished part in the elucidation of the hæmoglobin molecule".

THE Lawes Agricultural Trust Committee has appointed Dr. C. G. Johnson as head of the Entomology Department, Rothamsted Experimental Station, from October 1, in succession to Dr. K. Mellanby, who will become director of the Monks' Wood Experimental Station of the Nature Conservancy (see p. 488).

THE Right Hon. Lord Clitheroe has been appointed a vice-chairman of Tube Investments, Ltd. Sir Ben Lockspeiser, having reached retirement age, and Sir Francis de Guingand have resigned from the Board. Sir Francis is returning to the Union of South Africa, where he will continue to be in charge of Tube Investments interests in Southern Africa. Prof. J. M. Kay, professor of nuclear power at the Imperial College of Science and Technology, University of London, has been appointed to the Board of Tube Investments, Ltd., as director of research and development from July 1.

THE Academy of Sciences of the U.S.S.R. has issued two publications in Russia relating to the International Geophysical Year—(1) *Information Bulletin I.G.Y.*, No. 8, 1960. This contains a number of articles and reports on a variety of subjects such as geomagnetism, the ionosphere, glaciology and oceanography. (2) *Bibliography of publications relating to the I.G.Y.* (in Russian). This comprises some 800 items published in 1959, which are ordered and classified according to subjects.

THE third international symposium on "Phytopharmacy and Phytiatry" is being held at the State Agricultural University, Ghent, on May 9. Further information can be obtained from the State Agricultural University, Coupure Links, 235, Ghent.

THE National Physical Laboratory, Teddington, Middlesex, is organizing two open days during May 10–11. To be included in the programme are two lectures: "The N.P.L. and Industrial Measurement Standards", by Dr. H. Barrell; "Research in the Basic Physics Division", by Dr. J. A. Pople. Further information can be obtained from the Director, National Physical Laboratory, Teddington, Middlesex.

THE German Society for Polar Exploration is holding a meeting at Münster during May 11–14. The theme of the meeting will be "New Results in Polar Exploration", and it will include a symposium on "Scientific Problems of Exploring Greenland". Further information can be obtained from the Deutsche Gesellschaft für Polarforschung, E.V., Münster, West Germany.

THE International Atomic Energy Agency is organizing an international conference on "Nuclear Electronics", to be held in Belgrade during May 15–20. An exhibition is being organized in conjunction with the conference, and will be open during May 13–21. Further information can be obtained from the International Atomic Energy Agency, Vienna I, Austria.

A MEETING of the Biochemical Society is being held in University College and Trinity College, Dublin, during May 25–26. A meeting of the Association of Clinical Biochemists will follow at University College on May 27, and included in the programme is a symposium on "Acid-base Balance". Further information can be obtained from Dr. W. J. Whelan, Lister Institute of Preventive Medicine, Chelsea Bridge Road, London, S.W.1.

THE NATIONAL SCIENCE FOUNDATION, WASHINGTON

ANNUAL REPORT

THE tenth annual report of the National Science Foundation, covering the year ended June 30, 1960*, follows the pattern of the previous two reports. Besides the Director's statement and the chapter reviewing the Foundation's programmes for promoting basic research and education in the sciences (see p. 473) nearly half the report reviews the work of the Foundation during the year. The remaining half of the report consists of appendixes listing the members of the National Science Board, the Foundation's staff, committees and advisory panels, the grants made for basic research and other purposes, fellowship awards, publications, and the financial report.

Grants for research totalled 78 million dollars and the report summarizes briefly the programmes supported through the Foundation's Divisions of Biological and Medical Sciences, and of Mathematical, Physical and Engineering Sciences, its Office of Social Sciences, which for the first time operated for the full year; and, through the Office of Special International Programmes, in the Antarctic. Significant research developments in the year which are noted are the total synthesis of chlorophyll, the study of factors regulating behaviour in man, the discovery of the first synthetic antigen, the isolation and identification of the acetylcholine receptor protein from the electric tissue of the electric eel, the study of gravity response dependent on hereditary factors and the discovery that sub-units of a gene are arranged linearly within a gene. Progress has been made in determining the mechanism of action of vitamin B_{12}, the feasibility of studying bargaining behaviour in bilateral monopoly situations under controlled laboratory conditions has been demonstrated, and an archæological study of eastern Arizona has discovered evidence of a primitive people without pottery and probably without agriculture living in the midst of other tribes with far more advanced culture. A sensitive infra-red analyser has been applied to the measurement of atmospheric carbon dioxide, various isotope techniques are yielding important results in the study of undisturbed cores of sediment from the ocean bottom and a photoelectric image intensifier is giving significant help to astronomers.

Of the 1995 research grants made during the year, 891, totalling nearly 25 million dollars, were for biological and medical sciences; 916, totalling 31·5 million dollars, were for mathematical, physical and engineering sciences; 109, amounting to more than 2 million dollars, for social sciences, and 79, amounting to more than 3·5 million dollars, for Antarctic research.

During the year, in its seven fellowship programmes, the Foundation made 4,010 awards totalling 13·5 million dollars, of which 1,200 were pre-doctoral, 1,190 co-operative graduate fellowships, 580 summer fellowships for graduate teaching assistants, 180 post-doctoral fellowships, 75 senior post-doctoral fellowships, 285 science faculty fellowships for teachers, and 500 summer fellowships for secondary school teachers of science and mathematics. The Foundation also supported 649 institute programmes during the year. Of these, 412 were summer institutes attended by 22,000 teachers; 33 were academic-year institutes for 1,500 teachers and 209 were in-service institutes, attended by some 9,000 teachers on a part-time basis. Special projects in science education included programmes for secondary schools to foster interest in, and understanding of, science, mathematics and engineering, travelling science libraries, grants for visits of outstanding scientists to secondary schools, as well as special science demonstration lectures for secondary schools and a science clubs programme. Other programmes were concerned with undergraduate science education and supplementary training for teachers of science and the improvement of the content of courses.

The Scientific Man-power Programme of the Foundation makes available information on the resources of scientific technical personnel in the United States. A comprehensive report on the status of the scientific and technical man-power register, the Foundation's studies in this field and its projected plans for the future, was issued in January 1960. The Foundation's responsibilities in the dissemination of scientific information have also been extended, and besides endeavouring to improve the existing information services, the Foundation, through its Office of Scientific Information, is promoting a national research programme for developing techniques for handling information. As part of this effort it is vigorously fostering the co-ordination of effort in this field, both within the Federal Government and among private and professional organizations, while on the international level the Foundation has co-operated with the International Federation for Documentation and the Abstracting Board of the International Council of Scientific Unions; and has, with the European Productivity Agency, studied means for establishing a European Translations Centre. Projects in this field assisted during 1960 include a large-scale test programme at Western Reserve University for evaluating procedures developed for the automatic processing and searching of metallurgical literature; a programme on mechanization of processing and searching chemical literature, including research on the semantics of chemical literature; and the investigation of large files of information with a multi-level structure and self-organizing capability at the Electrade Corporation.

The Foundation, mostly through scientific societies, supports the translation, in whole or in part, of 45 Russian periodicals, and, in November 1959, sponsored a conference of editors and officers of 28 professional societies and academic institutions translating such periodicals to discuss means for improving the dissemination of translated periodicals among scientists in the United States. A series of national surveys on media of scientific communication was also launched, and some experiments with new publication techniques and methods were supported. The Foundation is now authorized to support international activities which may improve education in science in the United States.

* National Science Foundation, Washington. Tenth Annual Report for the fiscal year ended June 30, 1960. Pp. xiii + 310. (Washington, D.C.: Government Printing Office, 1961.) 1 dollar.

THE INTERNATIONAL ACADEMY OF ASTRONAUTICS

THE International Academy of Astronautics, which now has a total membership of 76, coming from eighteen countries, was created by the International Astronautical Federation at Stockholm in August 1960, for the purpose of promoting the advancement of astronautical sciences. The Academy is working under a grant from the Daniel and Florence Guggenheim Foundation, and the French Government has provided offices for the Secretariat of the Academy in Paris.

The director of the academy is Dr. Th. von Kármán (United States) and the deputy directors are Prof. J. Pérès, dean of the Faculty of Sciences of the University of Paris, and Dr. F. J. Malina (United States). The initial membership of the Academy included 45 members, mostly leaders in space flight and in sciences related to astronautics. Prof. Niels Bohr has been elected the first honorary member of the International Academy of Astronautics.

The Academy has recently elected the following new members:

Basic Sciences Section: Prof. J. Bartels, University of Göttingen; Prof. D. R. Bates, Department of Applied Mathematics, Queen's University, Belfast; Prof. L. Biermann, director, Max Planck Institute for Astrophysics; Prof. S. Chapman, High Altitude Observatory, Boulder; Dr. H. Friedman, Atmosphere and Astrophysics Division, United States Naval Research Laboratory, Washington; Prof. L. Goldberg, Harvard College Observatory, Cambridge, Mass.; Dr. H. E. Newell, deputy director, Office of Space Flight Programs, National Aeronautics and Space Administration (United States); Prof. F. L. Whipple, Harvard College Observatory, Cambridge, Mass.

Engineering Sciences Section: Dr. A. Busemann, Langley Research Center, National Aeronautics and Space Administration (United States); Prof. E. Carafoli, director, Institute of Applied Mechanics, Bucharest; Prof. L. Crocco, director, Jet Propulsion Center, Princeton University; K. A. Ehricke, Convair Astronautics Division (United States); Prof. A. Ferri, Polytechnic Institute of Brooklyn; Prof. A. R. Kantrowitz, director, Eveo Everett Research Laboratory (United States); Mr. M. J. Lighthill, director, Royal Aircraft Establishment, Farnborough; Prof. M. Roy, director, Office National d'Etudes et de Recherches Aéronautiques (France); Dr. H. S. Seifert, Stanford University; Dr. E. Stuhlinger, director, Research Projects Division, National Aeronautics and Space Administration, George C. Marshall Space Flight Center (United States); Dr. Martin Summerfield, Princeton University.

Life Sciences Section: Dr. R. Grandpierre, director, Aviation Medicine Research Center (France); Prof. U. S. von Euler, Department of Physiology, Karolinska Institutet; Dr. A. Graybiel, director of research, U.S. Naval School of Aviation Medicine (United States); Prof. T. Lomonaco, director, Research Centre for Aviation Medicine (Italy); Prof. R. Margaria, former director, Research Centre for Aviation Medicine (Italy); Dr. H. J. Schaefer, Research Department, United States Naval School of Aviation Medicine; Prof. G. Schubert, Physiological Institute, University of Vienna; Colonel J. P. Stapp, Aerospace Medical Center, Brooks A.F. Base (United States); Air Commodore W. K. Stewart, Royal Air Force Institute of Aviation Medicine, Farnborough; Dr. P. M. Van Wulfton Palthe, National Aeromedical Centre (Netherlands); Sir Harold E. Whittingham, Chief Medical Officer, British Overseas Airways Corporation.

The next meeting of the Academy will be held in October 1961, in Washington, in conjunction with the annual congress of the International Astronautical Federation. During the meeting, the first Daniel and Florence Guggenheim International Astronautics Award will be presented. This international prize of £1,000 is to be given annually to an individual who has made outstanding contributions to astronautics during the five preceding years. The Academy will also review the work of the following committees: Publications, Awards and Fellowships, Lunar International Laboratory (LIL), and the Joint Commission of the Academy and the International Institute of Space Law on Technical Aspects of Space Law.

APPLIED BIOLOGY IN TECHNICAL COLLEGES

DEVELOPMENTS in the courses leading to the Diploma in Technology in Applied Biology at Bristol College of Science and Technology and at Brunel College of Technology, Acton, are described in the *Journal of the Institute of Biology* (8, No. 1; Jan. 1961).

The Diploma in Technology course in Applied Biology at Bristol began in October 1957 with eleven students, all college based. A previous survey had shown that opportunities for botanists and zoologists were very limited, but that there were increasing opportunities for trained biologists in the field of microbiology, pharmacology and biochemistry. The course was, therefore, arranged as a sandwich course for college-based students, designed to give a broad training in the early years with opportunity for specialization in the final year. As approved eventually by the National Council for Technological Awards, the course requires the study of botany, zoology, microbiology, physiology and chemistry in the first three academic periods in college, followed by biochemistry with a choice of either plant pathology, plant physiology, pharmacology, microbiology or entomology as a specialization in the final year, as well as a project occupying on average one day per week. General studies and tutorial work are an essential feature of the course.

The annual intake to the course is limited to between fifteen and twenty students. No student is admitted without interview, and, where it is felt that an insufficient number of suitable candidates present themselves, no attempt is made to fill the

course; academic qualifications required for entry are either two Advanced Level passes at the General Certificate of Education, or a good endorsed certificate in biology, but at least equal emphasis is placed on personality. Applications for admission to the course are now coming forward at the rate of fifty to sixty each year; of these a high percentage is made up of students who have been offered university places, but have preferred a course leading to a Diploma in Technology. At the same time, some students withdraw their applications on being offered university places, although this happened only in one case during 1960. There has been some wastage on the course arising from a variety of causes.

Co-operation with industry has been very close, and, during the three years for which the course has now been running, staff have been cordially received during their industrial visits. Some thirty-five firms offer industrial training at various levels and in various fields, and a number of other firms are anxious to co-operate as student numbers grow. Before a student is assigned to a particular firm, his or her interests are discussed with the head of department and the senior lecturer in biology, and the advice of various lecturers sought; an approach is then made to the firm able to offer the most appropriate kind of training and a suitable programme is drawn up. The student is then called for interview by the selected firm and a final decision is made as to the general suitability of arrangements. A member of staff from the firm is chosen to supervise the industrial training and to maintain contact with the College.

A tutor visits the student on two or three occasions, and mid-way through these industrial periods students are brought together for a residential week-end at some selected college outside Bristol, along with students from other Diploma in Technology courses. This provides an opportunity to meet the College staff and discuss matters of general interest.

The break of six months in academic work presents problems of continuity. Difficulties are to a considerable extent overcome by close consultation between industry and the College. Students leave college with some academic assignments involving guided reading and the writing of essays. Every care is taken to ensure that this does not create too much of a burden by holding a staff meeting at which the amount of work to be given to students is finally determined. Details of the assignments are given to the industrial tutors so that they are fully aware of the work to be done by a student during the industrial period; in some cases, time to do this work is allowed for in the general programme. Over and above this, a student is required to write an account of the industrial training and of its relevance to the particular industry in which he finds himself.

This course, despite some initial difficulties, is proving to be of considerable value to students, and, while there is still room for experimentation, the general pattern is sound. All the present fourth-year students are assured of appointments on completing their course, and an increasing number of firms are willing and anxious to co-operate.

The course for the Diploma in Technology in Applied Biology also began at the Brunel College of Technology in October 1957; and, although the subjects studied differ in detail from those at Bristol, the general arrangements follow the same pattern.

TREE PLANTING IN THE NATIONAL PARKS

A PUBLICATION has recently been issued jointly by the Standing Committee on National Parks of the Councils for the Preservation of Rural England and Wales and the Joint Action Group for the Protection of Dartmoor and Exmoor, entitled *The Case for Control of Afforestation of Open Land in National Parks**.

The problem of land use in our heavily populated island becomes yearly more and more complex. The public memory is short, and even those who are capable of pre-vision and of determining what is desirable in the long run cannot convince Governments of the appropriate action. This is especially true of tree-planting in its various aspects. Apart from a fraction of the land-owning class of earlier centuries it is unfortunately true that those in control have always been uninterested in, even antipathetic to, forestry as a commercial undertaking at home—so long as there existed readily available supplies of timber abroad. But for the lessons of two World Wars it is very doubtful if a State forest service would ever have been set up in Great Britain with the task of creating new forests and conserving existing woodlands. Since its establishment in 1919, the Forestry Commission has made good progress with its main task and its activities are widespread over most of Britain. It has clashed here and there with various land users, but, on the whole, its work is appreciated.

It would be wrong to imagine, however, that the Government has some overall plan for land use and that the various authorities who have an interest in land use are centrally controlled. It is not even the case that all the statutory authorities concerned in any way with tree conservation, tree-planting, afforestation and forestry are centrally controlled. Besides the Forestry Commission, in Britain, the following public bodies are interested in trees in one way or another—the local planning authorities under the Town and Country Planning Act of 1947, the Nature Conservancy, and the National Parks Commission. In addition, there is now the Timber Growers Association of private individuals engaged in commercial tree-planting enterprises. In some respects their interests clash, especially when the problem of conservation of amenities arises.

It is not a good thing that the various bodies interested in woodlands for various reasons should quarrel among themselves; they should be in the closest association, so that the woodland heritage can be preserved and extended, wherever possible, to fulfil to the best advantage all the recognized functions of protection, amenity, recreation and production. Hitherto, the tendency has been for

* Standing Committee on National Parks and Joint Action Group. *The Case for Control of Afforestation of Open Land in National Parks*, presented by the Standing Committee on National Parks of the Councils for the Preservation of Rural England and Wales; and the Joint Action Group for the Protection of Dartmoor and Exmoor. Pp. 24. (London: Standing Committee on National Parks, 4 Hobart Place, S.W.1, 1961.)

State action to concern itself too much with the commercial aspect of tree-planting. Afforestation has been almost entirely directed towards the establishment of short term 'crops' of trees and not to permanent woodlands adapted to satisfy demands for amenity, recreation and protection. In harmony with this tendency special fiscal concessions are given to private woodland owners who engage in commercial forestry. Taxation, in relation to tree-planting in Britain, is not easy to understand, more especially as the tree grower is also entitled to certain grants in aid. The Government takes with one hand and gives with the other, and it is not very clear why. A case can be made for State assistance to recreate forests, and a case can be made for a simple single basis of taxation of commercial forests, namely, on the profits of the enterprise instead of on the timber capital; but it is extremely difficult to segregate the commercial forest from the amenity woodland and to say how the State should act in relation to the latter. The ideal woodland is that which fulfils the triple functions of protection, amenity and production, and many landowners could teach the Forestry Commission a lesson to that effect.

The fiscal concessions allowed to tree-growers have led to a striking and relatively recent development in forestry circles. Commercial afforestation enterprises have been set up and have become especially active in southern England and Wales. The task which they have set themselves would not be financially attractive—it would not be economic—without the subsidies and fiscal concessions at present allowed. How successful these afforestation enterprises will be eventually, that is in the establishment of healthy permanent woodland, remains to be seen. Like the greater part of the Forestry Commission plantations they are, taking the long view, still experimental. If they pay the entrepreneurs it is solely because of the State assistance and taxation reliefs.

The position in respect of subsidies for tree-planting and of taxation relief to woodland owners certainly requires to be reconsidered: but whether it is desirable to give the Standing Committee on National Parks over-riding control on afforestation in such a way as to conflict with the duties of the Forestry Commission, or in any other way, is very doubtful.

The case for establishing such a control is put in a memorandum distributed by the Standing Committee on National Parks of the Council for the Preservation of Rural England and Wales and the Joint Action Group for the Protection of Dartmoor and Exmoor. They view with alarm the incursion of commercial afforestation into the Dartmoor and Exmoor National Parks in particular. They have a case. The solution does not lie, however, in resisting such encroachments but in trying to ensure that the State assistance on which the intruders depend is devoted to the creation of a type of forest which increases the amenities of the Parks while at the same time being productive.

There is no reason why the creation of these woodlands should result in the "squandering of any noble heritage of beauty" except in so far as the methods adopted are inappropriate. It is unfortunate that until recently State forest policy had subordinated too much the important protective and amenity functions of woodlands to the purely commercial function of producing timber, because it has placed the Forestry Commission in a weak position when it comes to discussing the best use of tree-planting associated with national parks.

In respect of Britain as a whole there are many districts where an afforestation policy of this kind would be welcomed, and which might benefit greatly from what is in effect the local expenditure of taxation revenues indirectly through the medium of private enterprise. Whether this is really a healthy development from the point of view of forestry is another matter. The production of figures in a book is a very different skill from that of creating and conserving a forest on the ground.

M. L. Anderson

PARENTS' VIEWS ON EDUCATION

During the past three years Political and Economic Planning has been carrying out an inquiry to determine how far the social services are meeting the needs of the people who use them.

Of the social services none can affect the life of the individual and the nation more radically than education, and, as a preliminary to a fuller report to be published later, Political and Economic Planning has produced a broadsheet recording the findings of the inquiry on the education service*. Since the object of the survey was to present the consumers' view of the social services, the broadsheet's approach to the education service must necessarily be a limited one. Parents' wishes cannot be equated with educational need. Parents may over-rate their children's abilities, or they may not understand what the school is trying to do. Nevertheless, it is part of the new plan for education that the parent should become more closely involved in the child's schooling. An understanding of parents' experience and opinions is, therefore, essential when considering the present achievements of the education service.

The main inquiry was carried out among families living in the Greater London area. It had been decided that the inquiry must be concentrated in one district and that the locality chosen should be a large urban area since this is the type of community in which most people live. It should also be large enough to contain a diverse population and to include several local authority areas with a variety of different arrangements for some of the social services. Greater London fulfilled all these requirements. To make sure, however, that the findings for London were not untypical of the rest of Britain, a second smaller inquiry was carried out in Northampton, a provincial town of quite different size. This second inquiry confirms that the London findings can be considered representative. A total of 734 families was successfully interviewed in the main inquiry. Since the social services to-day are not primarily concerned with hardship, or important only to limited sections of the population, it had been decided to study samples of all families with children under the age of 16.

* *Planning*, Vol. 27, No. 448 (January 23, 1961): Parents' Views on Education. Pp. 1–32. (London: Political and Economic Planning, 1961.) 3s. 6d.

It is evident from the answers received during the survey that there is now considerable interest in education and appreciation of its possibilities. The mothers showed concern with the kind of school attended by their children, and they had often decided that there was some particular form of higher education or specific training that they would like their children to have. A high proportion of those with older children said that they wanted them to stay at school after they were fifteen. Although interest was greatest at the top of the occupational scale, it was also strong among the operative groups. It would appear that the attitude towards education at all levels of society is becoming more positive. A higher standard of living together with smaller families has lessened the necessity for working-class parents to turn the child into a wage-earner as soon as possible. Instead, there is a wider realization that educational qualifications may be a valuable investment and that very wide opportunities may be open to the talented child. The old grudging attitude towards the school as a place in which children were detained when they might usefully have been out at work appears to be dying.

Although the prevailing attitude towards the education service is not an unfavourable one, there is a substantial section of unsatisfied demand for particular schools. There was no intention during the inquiry to set up arbitrary standards in the field of education and to test whether or not these were reached in the families in the sample. Nevertheless, it was a general principle in the Education Act that parents should be able to get the kinds of schools and education for their children that they think the children need. Altogether 17 per cent of the mothers in the inquiry said that they had failed to get particular types of school that they had wanted. Six per cent were thinking of nursery schools and 7 per cent of secondary schools (mainly grammar and technical). There may be differing views on whether or not there is a real need for these services as distinct from a demand for them; the need for expansion and improvement in these two fields has already been accepted by the community and incorporated in the Education Act of 1944. While the proportions of present-day demand are small in comparison with the total sample, they are considerable when compared with the proportions who had used the types of school in question. (Five per cent of the families had used nursery schools, 12 per cent grammar schools and 6 per cent technical schools.)

The demand for grammar and technical schools and also, in some cases, the use of private schools, appears to be the result of parents' dissatisfaction with secondary modern schools. Some of their comments suggest that they regard the secondary modern school as offering inferior academic education and as not providing a specific enough training for a particular job. If the objects of the 1944 Education Act are fully realized and secondary modern schools come to be recognized as enjoying the equality of facilities and staffing with grammar schools, it seems possible that the demand for grammar schools may decrease. Similarly, if secondary modern schools play their part in the provision of technical education then parents are less likely to feel that their children are missing opportunities for occupational training. The present situation, in which certain secondary schools are obviously considered superior to others, is socially undesirable and harmful to the successful as well as the unsuccessful children.

It is important, however, that parents should be able to arrange for a grammar school place for those children who should benefit from it. One feature that emerges from the Political and Economic Planning survey is that at present the education service is being used most advantageously by families at the top of the social scale. The managerial and professional group and the supervisory and technical group have been more successful than others in obtaining grammar school places for their children. It is the managerial and and professional group that shows the strongest awareness of education.

The desire for further information is strong among the other groups, however, and the disparate use of the service cannot be entirely accounted for by less interest in education among these groups. When parents at the bottom of the occupational scale would prefer a grammar school place for their children they are, nevertheless, less likely to obtain it. It seems that there are a number of parents failing to get the education they would like for their children because the education itself is beyond their own experience.

The demands which parents make on the education service on behalf of their children may sometimes be unreasonable or because they are inadequately informed. On one hand, parents may identify their own social prestige too closely with their children's achievements or, on the other hand, they may be too little aware of the ends and means of education. It appears, for example, that the mothers questioned in the survey were concerned predominantly with the jobs their children would get and not with the enrichment of their personality. Nevertheless, it is important that parents should feel reasonably satisfied with their children's education.

TERRESTRIAL SPECTROSCOPY

By Prof. C. L. PEKERIS, Z. ALTERMAN and H. JAROSCH

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THE discovery of the Zeeman effect in 1896 came at a time when the basic concepts needed for its interpretation had been worked out by Lorentz[1]. Already in his first paper[2], Zeeman reported a verification of the polarization of the lines, an effect which Lorentz had advised him to look for. He gives a derivation, on the basis of the Lorentz theory, of the formula for the splitting of the original frequency σ_0 by a magnetic field H:

$$\sigma = \sigma_0 \pm \frac{eH}{2mc} \qquad (1)$$

This relation had been derived independently by Larmor. Larmor proved[3] that the effect of a mag-

netic field on the orbit of a charged particle is analogous to the effect of rotation on the frequency of a mechanical system. While the Zeeman effect provides ample verification of the electromagnetic part of Larmor's analogy, an experimental demonstration of the mechanical counterpart has been wanting. A striking case of the splitting of the natural frequency of a purely mechanical system by rotation presented itself recently when the records of the Great Chilean earthquake of May 22, 1960, were analysed. This earthquake excited the natural oscillations of the Earth. The gravest modes $n = 2$ (53·7 min.) and $n = 3$ (35·5 min.) appeared as doublets in the spectra of both the gravimetric records[4] and the strain-meter records[5].

The free oscillations of the Earth are governed by gravitational and elastic forces. Taking the distribution of density $\rho(r)$, and of the elastic constants $\lambda(r)$ and $\mu(r)$, as inferred primarily from seismic as well as from other geophysical data, we have determined the terrestrial spectrum for several proposed models of the Earth[6-9]. The periods deduced from spectral analysis of the strain-meter records (52 lines) agreed with the gravimetric values (49 lines) to within 1 per cent; and this was also the measure of agreement with the theoretical spectrum[9] for the Gutenberg model of the Earth, and to a lesser extent with the spectrum for the Bullen B model. Free modes ranging from spherical harmonic order $n = 2$ up to $n = 38$ were identified seismically, and up to $n = 41$ gravimetrically.

We have investigated the effect of rotation on the spectrum of the Earth by carrying out a first-order perturbation calculation in the parameter $\varkappa = \omega/\sigma_0$, where ω denotes the angular rotation of the Earth. In the absence of rotation, the components of displacement u_0, v_0 and w_0 in a spherical system of co-ordinates (r, θ, φ) are given by:

$$u_0 = U_0(r)Y_{nm}, \quad v_0 = V_0(r)\frac{\partial}{\partial\theta}Y_{nm} \qquad (2)$$

$$w_0 = \frac{V_0(r)}{\sin\theta}\frac{\partial}{\partial\varphi}Y_{nm}, \; Y_{nm}(\theta, \varphi) = P_n^m(\cos\theta)\exp im\varphi \qquad (3)$$

where a factor $\exp i\sigma t$ has been omitted. The characteristic frequencies $\sigma_0(n)$ are degenerate, and do not depend on the azimuthal number m. The introduction of a slow rotation $\omega(\ll\sigma_0)$ removes the degeneracy, each line $\sigma_0(n)$ being split into $(2n + 1)$ lines σ_n^m given by:

$$\sigma_n^m = \sigma_0(n) + m\tau(n)\omega \qquad -n \leq m \leq n \qquad (4)$$

with

$$\tau(n) = \frac{\int_0^a \rho r^2(2U_0V_0 + V_0^2)dr}{\int_0^a \rho r^2[U_0^2 + n(n+1)V_0^2]dr} \qquad (5)$$

in the case of spheroidal oscillations, and

$$\tau(n) = \frac{1}{n(n+1)} \qquad (6)$$

in the case of torsional oscillations.

Table 1 gives the periods in the multiplets for the oscillations of spherical harmonic order $n = 2$ and 3 of the Bullen B model. These are based on the previously determined values[7] of $\sigma_0(n)$, and on equations (4) and (5). Also shown are theoretical intensities of the gravimetric and strain-meter lines for an observing station at Los Angeles ($\theta = 56°$). These were determined on the assumption of an explosive compressional point-source at the earthquake focus in Chile ($\theta_0 = 128°$).

Table 1. Theoretical and Observed Multiplets for Los Angeles, $\theta = 56°$

n	m	T_{nm} (min)	Amplitude: Gravimetric	Amplitude: Strain	Observed periods: Gravimetric (ref. 4)	Observed periods: Strain (ref. 5)
2	−2	55·33	0·115	0·302	54·98	54·7
2	−1	54·50	0·242	0·615		
2	0	53·70	0·0015	0·0023		
2	1	52·92	0·242	0·615	52·80	53·1
2	2	52·15	0·115	0·302		
3	−3	35·99	0·396	0·401		
3	−2	35·83	1·257	1·46	35·87	35·9
3	−1	35·67	0·282	0·377		
3	0	35·50	0·624	0·873		
3	1	35·34	0·282	0·377		
3	2	35·18	1·257	1·46	35·24	35·2
3	3	35·03	0·396	0·401		

As for the periods, the feature of interest is the observed interval between the doublets, rather than the central frequency, since the latter depends on the particular Earth model assumed. We note the following:

(1) *Gravimetric*. In the case $n = 2$, the central line $m = 0$ should be very weak, and was actually not observed. The theoretical interval between the strongest $m = -1$ and $m = 1$ lines is 1·6 min., as against the observed interval of 2·2 min. Since, however, the $m = \pm 2$ lines are theoretically half as strong as the $m = \pm 1$ lines, the observed lines may represent the unresolved pairs $m = 1$ and 2. The average periods of the pairs, weighted according to their amplitudes, are 54·77 min. and 52·67 min., giving an interval of 2·1 min., which is close to the observed interval of 2·2 min.

In the case $n = 3$, the strongest lines should be the pair $m = \pm 2$, which are very close to the observed two lines. The $m = 0$ line should be half as strong, and should have been observed if the noise-level were low enough and the resolution adequate.

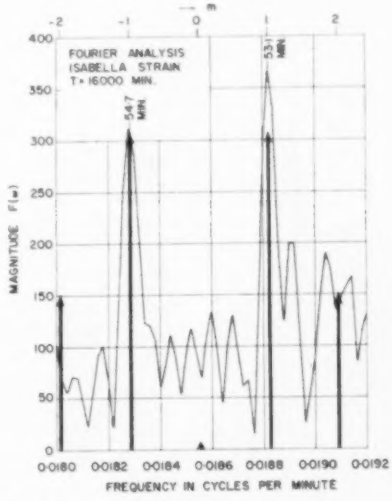

Fig. 1. $n = 2$. Arrows show positions and amplitudes of multiplet. ——, Spectral intensity of Chilean earthquake observed at Isabella by Benioff, Press and Smith (ref. 5)

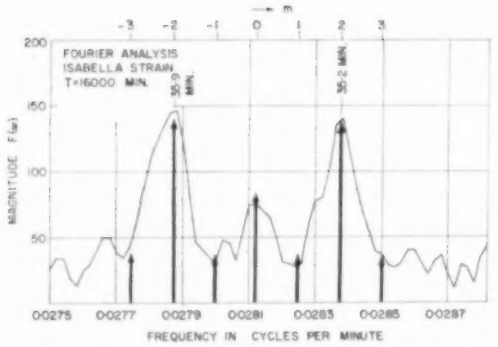

Fig. 2. $n = 3$. Arrows show positions and amplitudes of multiplet. ——, Spectral intensity of Chilean earthquake observed at Isabella by Benioff, Press and Smith (ref. 5)

In addition to the doublets in the fundamental $n = 2$ and $n = 3$ modes, the first overtone of the $n = 3$ mode was also reported[4] as a gravitational doublet: $T = 17{\cdot}88$ min. and $17{\cdot}68$ min. Theoretically, the relative amplitudes within a multiplet for the overtones should be the same as for the fundamental, as given in Table 1. The strongest lines in all the overtones of $n = 3$ should therefore be again the pair $m = \pm 2$. The period-interval for the pair comes out 0·19 min., in agreement with the observed value of 0·2 min.

(2) *Seismic.* Two doublets were reported by Benioff, Press and Smith[5] from a Fourier analysis of the strain seismogram at Isabella, California. In Fig. 1 is reproduced their spectral intensity curve in the vicinity of the $n = 2-$ pair of 54·7 min. and 53·1 min. In the same diagram are shown, by arrows, the theoretical separations and amplitudes of the five lines making up the $n = 2$ quintet, in accordance with the results given in Table 1. The central $m = 0$ line should be extremely weak, and is indeed below the background noise. The $m = 2$ line is not far from the observed intensity-level. On the other hand, the $m = -2$ line is definitely above the observed intensity in its vicinity. One would expect a rise in intensity immediately to the left of this line, which is outside the limit of the figure.

In Fig. 2 are shown the observed spectral curve for $n = 3$, and the theoretical positions and amplitudes of the $n = 3$ septet. The central $m = 0$ line is defined, and its theoretical intensity is close to the observed value. The $m = \pm 1$ and ± 3 pairs are close to the general noise-level in their respective neighbourhoods.

It is seen that, in general, the doublets observed are those lines of the multiplet which are strongest theoretically, and that the missing lines would not be expected to stand out above the observed noise-level.

This investigation was supported by the Office of Naval Research and Project VELA-UNIFORM of the Advanced Research Projects Agency.

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FLUORESCENCE OF TETRACYCLINES IN BONE TUMOURS, NORMAL BONE AND TEETH

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FOLLOWING the observations on the localization of the tetracyclines in bone by Milch, Rall and Tobie[1], other workers have used the tetracyclines as bone markers and have also studied under ultra-violet light the fluorescence produced by these compounds in various pathological lesions, including bone tumours and other neoplasms. Some recent investigations on this subject are described in this communication and will be published in detail elsewhere.

The source of ultra-violet light was a Wood's mercury vapour lamp as used in the diagnosis of ringworm. Photographs were made on high-speed Ektachrome film using a Wrayflex camera, with a Wratten 2*E* filter, with the object at about 30 cm. distant from both the light source and the camera. Exposure times were usually about 4 min. A Leitz fluorescence microscope with a Philips 150-watt mercury vapour lamp was used for the histological examinations.

A group of rats, seven weeks old, was subjected to fracture of the left tibia with the intact fibula acting as a splint during repair. Animals were killed at intervals of 3 days. 24 hr. before death they were injected intraperitoneally with chlortetracycline. Yellow orange fluorescence could be detected in the fracture callus from the ninth day onwards. When young rats with deep yellow-orange fluorescent bones due to previous administration of chlortetracycline were subjected to fracture of the tibia and no more chlortetracycline administered the resulting callus, in contrast to the fracture fragments, showed no fluorescence. Following the injection of chlortetracycline into older rats with osteomyelitis of the femur the new bone fluoresced yellow while the older normal bone showed only blue autofluorescence. Normal bone laid down in drill holes made in the femur a year previously did not fluoresce.

Sarcomata produced 8 months after implantation of methylcholanthrene crystals into drill holes made in the femur of rats showed no fluorescence, but roughened areas of new bone adjacent to the original drill holes fluoresced bright yellow. Osteosarcomata *D*177 showed yellow fluorescence, but the bones of these animals showed only normal blue auto-

fluorescence. Sarcomata produced by the sub-cutaneous implantation of plastic disks 2 cm. in diameter did not fluoresce.

Normal rats about 19 days pregnant were injected intramuscularly with chlortetracycline and killed 24 hr. later. Gross examination of the fetuses showed marked yellow fluorescence in both 'membrane bone' and 'cartilage bone' demonstrating crossing of the placental barrier by the drug. Young female rats dosed heavily with chlortetracycline prior to mating and the bones of which fluoresced bright orange-yellow under ultra-violet light produced fetuses the bones of which showed no fluorescence.

A normal dog, eight weeks old, was dosed regularly with 750 mgm. chlortetracycline on six days a week for a month. Following eruption of the permanent teeth these appeared pale yellow in daylight as compared with the teeth of normal litter mates, and there was intense yellow fluorescence under ultra-violet light. On histological examination both dentine and enamel were found to fluoresce. Four narrow bands of non-fluorescent dentine occurred in the wide band of fluorescent dentine and probably correspond to the Sundays when no chlortetracycline was administered (Fig. 1).

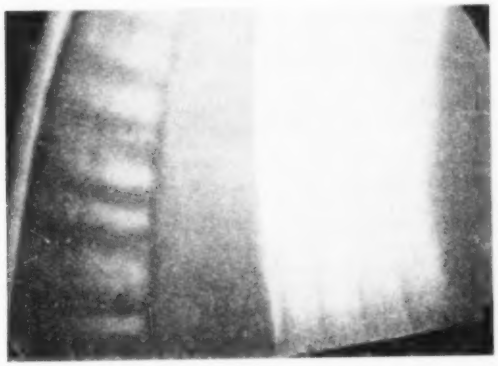

Fig. 1. Section of incisor tooth of dog showing fluorescence of Schreger's lines of the enamel (left) and fluorescent bands in the dentine (right), following chlortetracycline administration (× c. 30)

Chlortetracycline was administered to a 5-month old Great Dane with a condition indistinguishable from osteogenesis imperfecta. Examination of the bones at death three days later showed the very thin cortices to fluoresce in a similar manner and intensity to that seen in young dogs with normal thickness of cortex. The epiphyseal line showed normal blue autofluorescence.

A Great Dane weighing 60 kgm. and with spontaneous osteosarcomata of the distal radius and ulna in both fore limbs had previously had these limbs perfused with nitrogen mustard, using an extra-corporeal circulation[2]. An increase in size of the tumour in the right radius was noted 5 months later and the animal was killed. About 18 hr. prior to killing 1 gm. of chlortetracycline hydrochloride was given intravenously and 1 gm. orally but an unknown quantity of the oral dose was later lost by vomiting. On post-mortem examination brilliant yellow fluorescence was seen under ultra-violet light in the area of new bone in the tumours of the fore limbs both in the medullary cavity and as extensions from the periosteum (Fig. 2). This

Fig. 2. Longitudinal section of the right distal radius of a Great Dane showing fluorescent areas of new bone in the osteosarcoma. The adjacent normal bone showed no yellow fluorescence but is clearly visible on the photograph because of its normal blue autofluorescence. (× c. 1/3)

fluorescence was much brighter than the orange fluorescence which has been observed in fracture callus of dogs following administration of tetracyclines. Areas of non-osteogenic tumour tissue, which were of a rubber-like consistency, did not fluoresce. Normal bone adjacent to the tumour showed only blue autofluorescence. Brilliant yellow fluorescence also occurred in the osteogenic areas of a metastasis in the right axillary lymph node (Fig. 3) and in a small and previously unsuspected area of malignant new bone in the left tibia. This latter area was difficult to detect in daylight but under ultra-violet light the narrow band of yellow fluorescence was very striking. Two small metastases in the lungs, undetectable by radiography, did not fluoresce, and on microscopical examination were found to consist solely of sarcoma cells with no osteogenic tissue. The only normal soft tissues showing appreciable fluorescence were the testicles, which showed a dull yellow fluorescence tinged with green.

A greyhound with an osteosarcoma of the proximal tibia was injected intravenously with tetracycline hydrochloride (20 mgm./kgm.) and four days later was killed. Yellow-orange fluorescence was particularly noticeable on the large new areas of bone attached to the tibia but also occurred in smaller osteogenic areas in the tumour tissue. Other tissues showed no similar fluorescence and no metastases were discovered in this dog.

Fluorescence of tetracyclines in new bone as opposed to normal soft tissues in dogs persists for

Fig. 3. Section through the right axillary lymph node of the same dog showing fluorescent areas of tumour bone. (× c. 3)

long periods of time. Older normal bone shows only blue autofluorescence. It would therefore seem possible that if tetracycline labelled with iodine-131 had been administered to the Great Dane with multiple osteosarcomata confirmation of a metastasis in the axillary lymph node would have been obtained. The scintillation counter would also have discovered the new focus of malignancy in the tibia but not the small non-osteogenic areas in the lungs.

Further work is planned to develop the therapeutic possibilities of radioactive or other destructive agents attached to the tetracycline molecule.

Rats bearing osteosarcoma *D*177 were generously supplied by Prof. Alexander Haddow from the Chester Beatty Cancer Research Institute. Lederle Laboratories, Ltd., gave the chlortetracycline ('Aureomycin') and tetracycline ('Achromycin'), and I am particularly grateful to Dr. Ruth Porter for arranging this and for her help in this investigation. Mr. A. R. Jennings kindly confirmed the diagnosis of the tumours.

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EFFECTS OF OLIGOMYCIN ON RESPIRATION AND SWELLING OF ISOLATED LIVER MITOCHONDRIA

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INTACT liver mitochondria oxidize substrate rapidly only when in the presence of adenosine diphosphate (ADP) or of an uncoupling agent such as 2 : 4-dinitrophenol (DNP). Since oligomycin inhibits oxidations of pyridine nucleotide-linked substrates in presence of the former and the inhibition is reversed by the latter, Lardy and his colleagues[1] have concluded that this antibiotic interferes with the enzyme system responsible for respiratory-chain phosphorylation. This is strengthened by the finding that it inhibits mitochondrial DNP-stimulated adenosine triphosphatase and the adenosine triphosphate – inorganic phosphate exchange, both of which are thought to involve enzymes of the phosphorylation system of the respiratory chain; it also prevents the loss of oxygen-18 from labelled inorganic phosphate. These further observations indicate that oligomycin acts on that part of the phosphorylation system which is involved in the uptake of inorganic phosphate.

Oligomycin has also been found to prevent the swelling of rat-liver mitochondria induced by inorganic phosphate, and DNP reversed this effect[2]. This seemed to be in conformity with the proposal[3,4] that swelling of this type occurs only when some measure of electron transport is proceeding. Since, however, the observations on swelling were made with media containing sucrose (0·3 *M*), which markedly inhibits the oxidation of some substrates[5], it was desirable that these latter effects of oligomycin should be re-investigated.

In a medium (*p*H 7·4) containing 80 m*M* potassium ions, 6 m*M* magnesium ions, 27 m*M* 2-amino-2-hydroxymethylpropane-1 : 3-diol, 92 m*M* chloride ions, 16 m*M* inorganic phosphate and 10 m*M* L-glutamate, and with the sucrose reduced to about 5 m*M*, oligomycin again prevented swelling, and subsequent addition of DNP initiated it. However, in the presence of ADP this effect of DNP was not seen; that is, with oligomycin present, a rapid swelling was caused by DNP alone but not by DNP together with ADP (Fig. 1*A*). Simultaneous measurements of respiration with the Clark oxygen electrode (technique to be described by J. B. C.) under identical conditions showed that, in the absence of adenine nucleotide and presence of oligomycin, respiration was not maintained after addition of DNP, but that addition of ADP before or shortly after the DNP prevented this decline in respiratory-rate (Fig. 1*B*). Adenosine triphosphate temporarily prevented the swelling induced by DNP in the presence of oligomycin and, also for a short period, the fall in respiration; we judge these effects to be due to ADP derived from the added triphosphate. If a very small amount of ADP is added after the DNP, the decline in respiratory-rate is delayed for only a short time: repeated small additions of ADP result in a stepwise curve (Fig. 2). Thus mitochondria treated with oligomycin

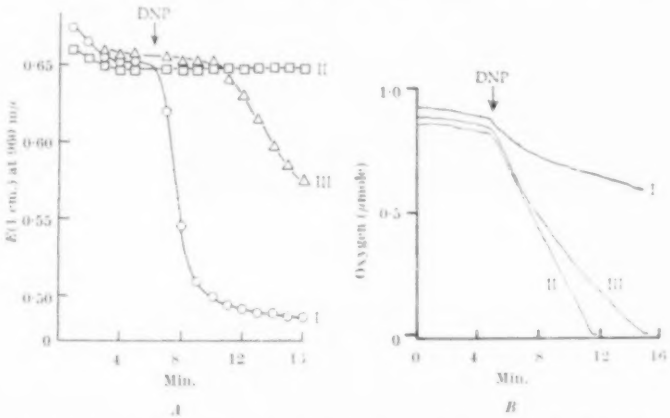

Fig. 1. Swelling (*A*) and respiration (*B*) of rat-liver mitochondria in presence of L-glutamate. In all runs, oligomycin (0·6 μgm./ml.) was present throughout and 2 : 4-dinitrophenol (0·04 m*M*) was added 5 min. after mitochondria (arrow). I, no adenine nucleotide added; II, 0·33 m*M* adenosine diphosphate added before mitochondria; III, 0·33 m*M* adenosine triphosphate added before mitochondria. Mitochondrial nitrogen, 0·11 mgm./ml. Other constituents of medium as in text. Total volume, *A*, 3 ml.; *B*, 4 ml. Temp. 25° C.

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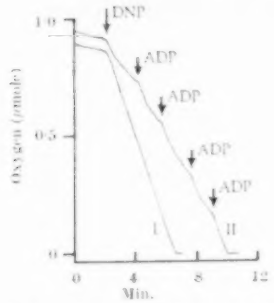

Fig. 2. Respiration of rat-liver mitochondria in presence of L-glutamate, 2:4-Dinitrophenol (0·04 m*M*) added at time shown by arrow. I, no addition of oligomycin or adenine nucleotide; II, oligomycin (1·2 γgm./ml.) present throughout, and additions of adenosine diphosphate as shown (12 μ*M* in the first three and 24 μ*M* in the last). In both runs, mitochondria equivalent to 0·2 gm. of liver in 4 ml. total volume; 1 m*M* ethylenediamine tetraacetate; other constituents of medium as in text. Temp., 25° C.

show some measure of respiratory control despite the presence of DNP. Results similar to those in Fig. 1*A*, *B* were obtained with ferricyanide instead of oxygen as terminal acceptor. The reduction of ferricyanide was followed by means of a smooth platinum electrode and automatic titrator (Radiometer, Copenhagen) (unpublished work by G. D. G. and J. B. C.).

Thus, in presence of oligomycin and DNP and with glutamate as substrate, ADP both maintains respiration and prevents swelling. The decline in respiratory-rate in the absence of adenine nucleotide appears to result from failure of the oxidation of the α-ketoglutarate formed from the glutamate, insufficient ADP being available for the obligatory phosphorylation at the substrate-level. The requirement for ADP when DNP is present is most likely to be related to this stage in the tricarboxylic acid cycle, since when the substrate was changed to β-hydroxybutyrate, L-malate, L-proline or succinate, addition of ADP was no longer necessary for the maintenance of rapid respiration. In fact, of the substrates tested, only glutamate, L-(+)-*iso*citrate and α-ketoglutarate showed the requirement for ADP. When succinate was substrate, in order to obtain rapid oxidation uninhibited by accumulation of oxaloacetate, amytal was added to inhibit oxidation of malate. When malate was substrate, oxaloacetate was removed by transamination with glutamate, β-chlorovinyl arsenious oxide (lewisite oxide) being added to stop oxidation of the glutamate and α-ketoglutarate (see later).

It can be deduced therefore that, with DNP present, ADP is not required for the oxidation of mitochondrial reduced pyridine nucleotide. The oxidation of α-ketoglutarate, on the other hand, requires ADP for the associated substrate-level phosphorylation. The ADP requirement for the oxidation of glutamate and *iso*citrate may be ascribed to the circumstance that these give rise immediately to an α-ketoglutarate. This implies that oxidation of glutamate and *iso*citrate cannot take place when α-ketoglutarate oxidation is prevented. This is indeed so, since low concentrations (for example, 0·5 μ*M*) of β-chlorovinyl arsenious oxide, which specifically interfere with the dehydrogenation of α-keto-acids, prevent the oxidation of glutamate and *iso*citrate as well as of α-ketoglutarate. Presumably the site of action of the arsenical is the lipoate involved in the dehydrogenation of α-ketoglutarate[6]. β-Chlorovinyl arsenious oxide does not inhibit glutamate dehydrogenase since, on addition of diphosphopyridine nucleotide together with cytochrome *c* and sufficient of the detergent 'Triton' to cause lysis of the mitochondria, oxidation of glutamate proceeds rapidly in the presence of the arsenical. It would appear that the inhibition of glutamate oxidation observed with intact mitochondria is due to accumulation of α-ketoglutarate, and that with particles treated with detergent glutamate oxidation is not dependent on the subsequent enzymatic removal of the keto-compound.

Krebs and Bellamy[7] have recently demonstrated a mechanism for the utilization of glutamate which involves transamination :

$$\text{oxaloacetate} + \text{glutamate} \rightarrow \text{aspartate} + \alpha\text{-ketoglutarate};$$

$$\alpha\text{-ketoglutarate} + 1\tfrac{1}{2}O_2 \rightarrow \text{oxaloacetate} + CO_2$$

$$\text{sum}: \text{glutamate} + 1\tfrac{1}{2}O_2 \rightarrow \text{aspartate} + CO_2$$

In this, the oxidation of glutamate to α-ketoglutarate is at most needed as a priming reaction. It is clear that any mitochondrial oxidation of glutamate by the mechanism of Krebs and Bellamy will likewise be inhibited by β-chlorovinyl arsenious oxide, since the reaction sequence is completely dependent on the oxidation of α-ketoglutarate. In presence of the arsenical, however, glutamate could still undergo oxidation to α-ketoglutarate were it not that this is prevented by accumulation of the product, as already indicated.

With *iso*citrate as substrate a further factor is involved. Oxidation of this substance depends on re-oxidation at the expense of oxaloacetate of the reduced triphosphopyridine nucleotide which is generated by the *iso*citrate dehydrogenase. In the presence of β-chlorovinyl arsenious oxide, the level of oxaloacetate is insufficient, but the further addition of catalytic amounts of malate leads to restoration of *iso*citrate oxidation[8].

Since ADP is required for the oxidation of α-ketoglutarate, glutamate or *iso*citrate, in the presence of DNP, only when oligomycin is also added, it must be inferred that (*a*) in absence of oligomycin, DNP ensures a supply of ADP from the endogenous adenine nucleotide adequate for the needs of the succinyl coenzyme A synthetase (*P*-enzyme), and (*b*) oligomycin reduces the production of ADP until this becomes the limiting factor. Presumably its inhibitory effect on DNP-stimulated mitochondrial adenosine triphosphatase[4] would account for this. The requirement for inorganic phosphate for DNP-stimulated oxidation of glutamate[9], and the similar requirement for *iso*citrate oxidation (unpublished work by J. B. C.), are seen to result from the demands of the *P*-enzyme. It was found that no added phosphate was required for DNP-stimulated oxidation of proline, succinate, malate or β-hydroxybutyrate.

It seems clear, therefore, that oligomycin, which inhibits respiratory-chain phosphorylation[1], does not affect substrate-level phosphorylation. It is interesting to inquire whether this antibiotic inhibits at each of the three possible sites of respiratory-chain phosphorylation. It is possible to isolate single phosphorylation steps corresponding to two of these. Thus (i) with succinate as substrate and ferricyanide as electron acceptor, and (ii) with *p*-phenylenediamine as substrate and oxygen as acceptor, ADP does not stimulate electron transport in presence of oligomy-

cin, although DNP does. Whether oligomycin exerts an inhibitory effect at the remaining phosphorylation site, namely, that adjacent to diphosphopyridine nucleotide, is at present unknown, although it is likely that it does, for the following reason. Oligomycin reduces the ADP-stimulated respiration with DPN-linked substrates to the corresponding state-4 rate (ref. 10), which is lower than the state-4 rate or the rate obtained in presence of ADP together with oligomycin in both cases (i) and (ii) mentioned above.

The decline in respiration in absence of adenine nucleotide (Fig. 1*B*), although due ultimately to failure of oxidation of α-ketoglutarate, is probably accentuated by loss of cofactors or other damage to the integrated mitochondrial respiratory system. Some evidence for this is as follows. If the concentration of the swelling agent, inorganic phosphate, was lowered from 16 m*M* to 2·5 m*M* or less, then, with oligomycin and DNP but no adenine nucleotide, addition of ADP after the respiratory-rate had fallen off re-instated the respiration ; but this did not occur with the higher concentration of phosphate. Furthermore, with some mitochondrial preparations, after swelling had occurred in the presence of DNP, oligomycin and 16 m*M* inorganic phosphate and absence of adenine nucleotide, addition of diphosphopyridine nucleotide and cytochrome *c* restored respiration, whereas with unswollen mitochondria a similar addition did not significantly increase the rate of DNP- or ADP-stimulated respiration.

It remains to be considered why, in presence of oligomycin, glutamate, DNP and a high concentration of phosphate, swelling occurs in the absence but not in the presence of ADP. It emerges from what has been said that in the absence of ADP an accumulation of α-ketoglutarate is to be expected. This would not occur in the absence of oligomycin, or in the presence of oligomycin together with ADP, since under these conditions α-ketoglutarate is oxidized. One is tempted to speculate that swelling in media which pre-dispose to this effect, for example, those containing high concentrations of phosphate, is connected with this accumulation of α-keto-acid.

To summarize, in a salt medium containing 16 m*M* phosphate and of low sucrose content, the respiration of rat-liver mitochondria in the presence of oligomycin and dinitrophenol is not maintained unless ADP is added as well. This phenomenon is observed with α-ketoglutarate, and with glutamate and *iso*citrate which give rise immediately to this keto-acid, but not with other substrates, and is ascribed to the requirement for ADP for substrate-level phosphorylation. Under these conditions the mitochondria swell rapidly in the absence but not in the presence of ADP, and damage to the respiratory system consequent on swelling may be a contributory cause of the decline in respiration.

We thank Miss Freda Johnson for expert technical assistance and Dr. A. S. Mildvan for criticizing the manuscript.

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OSMOTIC PRESSURE EFFECT OF THE RED BLOOD CELLS—POSSIBLE PHYSIOLOGICAL SIGNIFICANCE

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THE present concept of the net fluid volume transfer across the capillary wall rests mainly on the balance between the hydrostatic and colloid osmotic pressures as expressed in Starling's hypothesis[1]. The osmotic forces demonstrated in the conspicuous and well-known behaviour of the red blood cells as perfect osmometers[2–6] have not been invoked in attempts to explain the obvious inconsistencies between Starling's hypothesis and a series of common clinical observations related to oedema formation.

Osmotic Pressure Effect of the Red Blood Cells

During attempts to measure the colloid osmotic pressure of whole blood it became apparent that the red blood cells could influence the osmotic pressure under certain conditions in an electronic osmometer[7–9]. Fig. 1 shows the results of a single experiment. The first upward deflexion is due to the osmotic pressure generated by plasma when the reference fluid in the osmometer is 0·5 per cent sodium chloride. The very much higher pressure that follows develops when a sample of red blood cells concentrated by centrifugation in the same plasma is placed on the semi-permeable membrane, the reference fluid here also being 0·5 per cent sodium chloride. With plasma the pressure settles at a level of about 33 mm. mercury. When red blood cells form the sample the pressure decreases slowly after a maximum of about 400 mm. mercury has been reached. This is in accordance with the fact that the initial salt concentration difference between the reference fluid and the plasma remaining between the red blood cells is being eliminated by diffusion. The abrupt drop of pressure to the far right is caused by flushing with a 0·5 per cent sodium chloride solution. The effect of the salt concentration difference in the sample of the red blood cells is depending on the permeability of the membrane of the red blood cell, whereas the tiny and rapidly eliminated overshot in the plasma curve is the osmotic effect of the salt concentration difference across the semi-permeable membrane of the osmometer.

In Fig. 2 are shown semi-quantitatively a few principal experiments. The diagram can be interpreted as follows:

When the red blood cells are in close apposition to the semi-permeable membrane of the osmometer (*C*, *D*, *F*, *G*) but otherwise not (*E*), they exert an osmotic effect as if the semi-permeable membrane were replaced by a membrane having the osmotic characteristics of the membrane of the red blood cell. The difference between the osmolar concentration within the red blood cells and that of the reference fluid therefore determines the osmotic flow out of the measuring chamber and the resulting negative sub-atmospheric) equilibrium pressure (*C*, *D*, *F*, *G*). Differences in concentration of substances (as, for example, urea) which penetrate the red cell membrane exert no osmotic effect of their own and do not interfere with that of the salt (*G*). No hæmolysis was observed and hæmoglobin inside the red blood cell was found to be without colloid osmotic effect in the osmometer (*F* 0·9). The plasma protein in the space between the red blood cells exerts its usual colloid osmotic pressure (*B*) across the semi-permeable membrane (the low pressure in all the instances except *A* and *F*). The colloid osmotic pressure itself is not influenced by the various salt concentrations used (*B*). However, by restricting the amount of water available to the red blood cells outside the measuring chamber (*C* 0·5 as compared to *F* 0·5), the protein enhances the osmotic effect of the salt concentration differences.

The maximum osmotic pressure that can be developed by a sample of red blood cells equilibrated with a 0·9 per cent sodium chloride solution (310 milliosmolar) when the reference fluid is a 0·5 per cent sodium chloride solution (162 milliosmolar) is :

$$(310 - 162)\ 17 = 2{,}516 \text{ mm. mercury}$$

where 17 is the factor used for the conversion of concentration into pressure $\left(\frac{22{\cdot}4 \times 760}{1{,}000} = 17\right)$, when concentration is expressed in milliosmoles.

A volume transfer from the measuring chamber into the sample creates a negative pressure of 1 mm. mercury per 4×10^{-4} mm.^{3}.

The volume of one single layer of red blood cells on the semi-permeable membrane (area 40 mm.^{2}) is 4×10^{-2} mm.^{3}. The water phase is 0·6.

If all the water (V) is taken up from the measuring chamber we have the following equation at equilibrium pressure, where the subscript to V denotes the number of layers of red blood cells:

$$\frac{V_1}{4 \times 10^{-4}} = 2{,}516 - \frac{V_1 \times 310}{0{\cdot}6 \times 4 \times 10^{-2}}\ 17 \sim 30 \text{ mm. mercury}$$

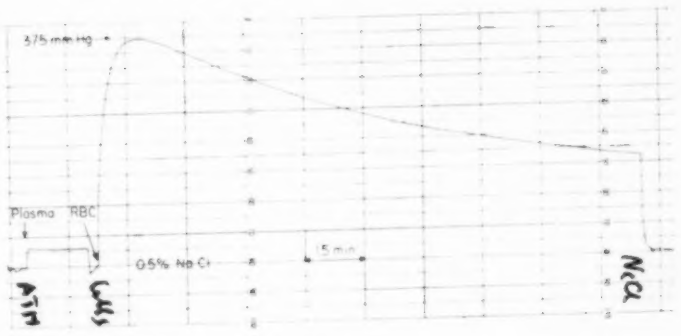

Fig. 1

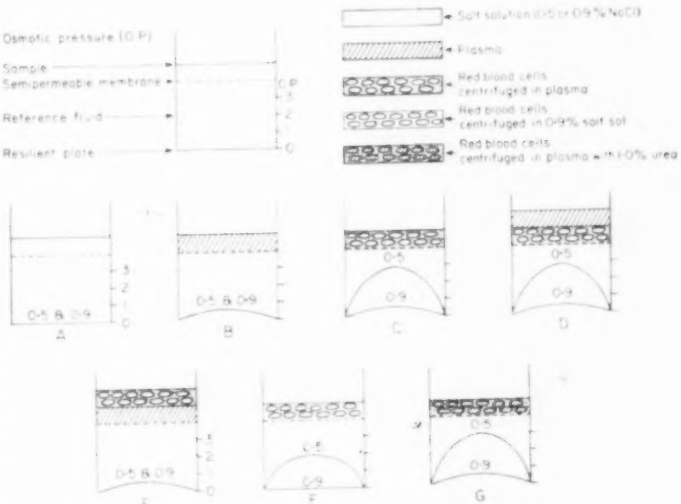

Fig. 2. The resilient plate is part of an electric capacitor. Its deflexion is detected by the change in capacitance to which it gives rise. The graduation shown on the pressure chamber of the osmometer is related to the order of magnitude of the actual pressures obtained rather than to exact values. The deflexion of the resilient plate is grossly exaggerated for the sake of distinction. The actual volume displacement is 4×10^{-4} mm.^{3}/mm. mercury

With 500 layers of red blood cells roughly equivalent to the usual samples the equation is:

$$\frac{V_{500}}{4 \times 10^{-4}} = 2{,}516 - \frac{V_{500} \times 310}{0{\cdot}6 \times 500 \times 4 \times 10^{-2}}\ 17 \sim 2{,}160 \text{ mm. mercury}$$

Considering that some water is available outside the osmometer, and that diffusion, as mentioned, tends to eliminate the original concentration difference, the actual maximum pressure values of 400–1,000 mm. mercury are acceptable as being of the same order of magnitude.

Red Blood Cells in the Capillaries

It has been tacitly accepted that the osmotic conditions in the capillaries are determined solely by the plasma and the capillary wall, leaving no role for the red blood cells, as already mentioned. The validity of this concept is not obvious when it is realized that the red blood cells often pass capillaries in close contact with the wall and tightly squeezed (Fig. 3),

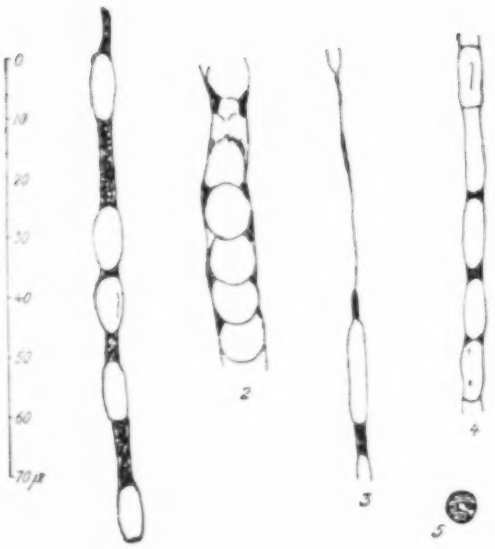

Fig. 3. Muscle capillaries from guinea pig, vitally injected with indian ink. Walls of capillaries not shown. (From A. Krogh, ref. 25)

and that the capillary wall and the tissue fluid are analogous to the semi-permeable membrane and the reference fluid of the osmometer respectively. In Fig. 4, (*a*) represents the present concept and (*b*) the situation in which the red blood cell may exert an osmotic effect across the capillary membrane. The dilatation of the capillary in case (*a*) is meant as symbolic only. However, the acceptance of the mechanism postulated in (*b*) would require it to be real in order that the same effect be obtained.

As an osmolar concentration difference between the red blood cell and the tissue fluid makes it easier to explain the transfer mechanism, blood is assumed to enter the capillary with a slightly higher salt concentration ($C + \Delta C$) than that existing in the tissue fluid (C). Osmotic equilibrium between plasma and red blood cells prevails at both ends of the capillary. For the sake of simplicity it is further assumed that: (1) the volume of the tissue fluid is equal to the water phase of the blood in the capillary; (2) the colloid osmotic pressure is balanced by the hydrostatic pressure throughout the capillary. In (*a*) any exchange across the capillary membrane is diffusional, and consequently no net volume transfer takes place. The protein is concentrated by a factor:

$$\frac{C + \Delta C}{C + \frac{\Delta C}{2}}$$

which is immaterial as ΔC is small. The volume change of the red cell is accomplished by a redistribution of water entirely within the capillary. In (*b*), however, the water is taken up from the tissue fluid by the red blood cells adjoining the capillary wall, presumably with little interference from this structure, which is known to offer less resistance to water flow than the membrane of the red blood cell itself[16]. In the plasma section of (*b*) diffusion equilibrium obtains as in (*a*). The plasma protein may enhance the effect of the red blood cells as in the osmometer. Its concentration remains unchanged.

Salt concentration differences between plasma and tissue fluid as assumed here are physiologically very probable as a result of resorption and excretion of salt and water. They are inherent in a concept of dynamic equilibrium and will lead to water transfer via the red blood cells in or out of the capillaries dependent on the direction of the concentration difference.

Even less hypothetical is the osmolar concentration gradient between the red blood cells and the tissue fluid that results from the respiratory function. The difference is a consequence of the increase of the osmolar concentration in the red blood cells as they pass along the capillaries releasing oxygen and taking up carbon dioxide. This is observable as a swelling of the red blood cells. Such a swelling of the red blood cells was discovered by Nasse[11] and observed both *in vitro* and *in vivo*, and has been studied among others by Hamburger[12], Warburg[13], Van Slyke[14] and Henderson[15]. Apart from the very minute effect it might have on the protein concentration[16,17] it has not been associated with important physiological functions, although Nasse felt that it was bound to be important. The osmotic effects of the phenomenon have been imitated by means of my technique (Fig. 5), and an estimate of the water transfer capacity is possible.

If Henderson's figures for the increase in volume of the red blood cell are used, we shall have for the resting person with an average arterio-venous oxygen deficit: measured volume increase of red blood cell 1 per cent, water phase 0·6. The total osmolar concentration is about 300 milliosmoles, the increase consequently 4·5 milliosmoles.

The total amount of water taken up by the red blood cells in 24 hr. at rest, assuming a haematocrit of 50 per cent and a cardiac output of 5 litres per min., will be:

$$\frac{5 \text{ litres} \times 24 \times 60 \times 50 \times 1}{100 \times 100} = 36 \text{ litres}$$

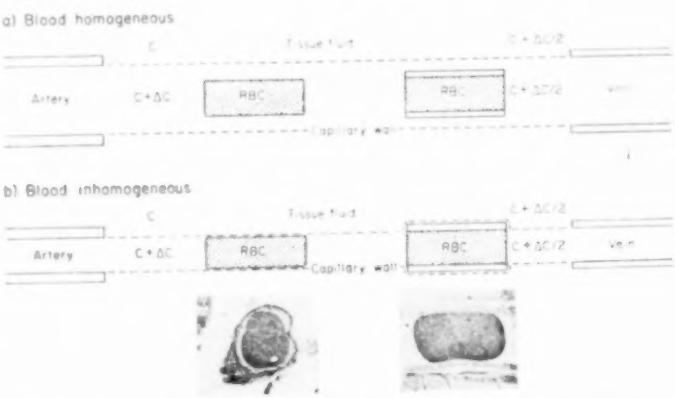

Fig. 4. The inserted photoelectron micrographs are from the heart of a rat. The completely solid appearance of the squeezed red blood cells is noteworthy. (The micrographs were kindly placed at my disposal by Dr. George E. Palade, Rockefeller Institute)

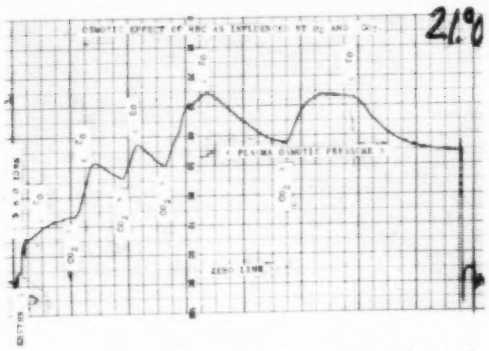

Fig. 5. Variation of the osmotic pressure of red blood cells under influence of carbon dioxide and oxygen. The aeration takes place from the surface of the sample not facing the semi-permeable membrane. This causes the effect to be relatively small and slowly developing

If all the capillaries were dilated as in Fig. 4*a*, all this water would be taken up from the plasma inside the capillary. If they were contracted as in Fig. 4*b* and we assign a length of 7μ and a radius of 1·5μ to the cylindrically deformed blood cell (Fig. 3), 8 litres would be taken up from the plasma across the two end surfaces and 28 litres across the capillary wall. This is still an amount that would seem to be abundant for any demand on water transfer across the capillary membrane, and certainly sufficient to remove the surplus of water formed metabolically in the tissue, which amounts to about 300 ml. per day. The mechanism is particularly suited for this task because the water-removing capacity of the red blood cells is proportionate to the oxygen metabolism, locally as well as totally. It should also be remembered that although the maximum capacity for water transfer seems very high indeed, any intermediate exploitation of the capacity between zero and maximum may be attained depending on the state of dilatation of the capillaries at any time and at any site.

The water taken up by the red blood cells from inside or outside the capillaries is in turn released in the lung capillaries. Any adverse effect of water transfer across the capillary wall into the tissue is prevented by the colloid osmotic pressure of the plasma, which is here in normal cases always in excess of the hydrostatic pressure—the only place in the organism where this is true. A small part, about 350 ml. in 24 hr., is excreted here as water vapour. In the glomeruli there is no deoxygenation of the red blood cells and, therefore, no interference with the filtration.

The red blood cells may take up water against a hydrostatic pressure in excess of the plasma colloid osmotic pressure, provided the wall supports it as the semi-permeable membrane does in the osmometer. The apparent effect would be that of a higher colloid osmotic pressure than the one measured *in vitro*. In the example in which the osmotic concentration rose 4·5 milliosmoles the equivalent pressure would be:

$$17 \times 4{\cdot}5 = 77 \text{ mm. mercury}$$

The suction effect is in addition to that of the colloid osmotic pressure, but the effect diminishes as water is taken up. If, therefore, the plasma section and the red blood cell section are of equal volume, the maximum excess of hydrostatic pressure that the red blood cells will be able to counteract is that which they can exert after they have taken up the water which has left the capillary in the plasma section. In my example it is about:

$$\frac{28}{36} \times \frac{77}{2} \text{ mm. mercury}$$

in excess of the colloid osmotic pressure. This pressure effect could easily be doubled within the physiological limits of deoxygenation.

Discussion

One of the reasons for this attempt to evaluate the hypothetical function of the red blood cells in some detail is its relation to net volume translocation across the capillary wall, which is now not satisfactorily understood[18–20].

In contrast to the exchange of solutes across the capillary wall, which can be accounted for by diffusion[10,21], net volume transfer requires hydrostatic or osmotic forces.

Starling's hypothesis provides for osmotic forces, and physiological experimentation has shown that fluid movement across the capillary wall can be brought about in agreement with the colloid osmotic pressure[1,22–24]. However, strictly speaking, such results only show that the capillary wall by and large is impermeable to proteins and freely penetrable for water and crystalloids, and that the colloid osmotic pressure is about the same as the hydrostatic average pressure in the capillaries. It does not seem permissible to infer that the hypothesis represents the sole mechanism by which net volume transfer between the vascular and the tissue fluid compartments takes place, and clinical observations, as mentioned in the introduction, make it clear that this is not likely.

A mechanism as the one discussed, based on an osmotic effect of electrolytes and closely associated with the capillary function (no matter how this function is conceived[25,26]) as well as with renal, respiratory and metabolic functions, would supplement the present concept of volume translocation in a very helpful way.

By invoking the surplus of suction effect of the red blood cells in contracted capillaries it would be easier to understand that a normal person does not accumulate œdema in the legs in spite of a capillary pressure here much higher than the colloid osmotic pressure[27]. In cardiac failure dilatation of the capillaries[28] as secondary to the well-known increase in vascular volume[29] would reduce the transcapillary osmotic effect of the red blood cells and thus explain why œdema develops, although the capillary pressure is not materially higher than in normal people.

Nephrotic œdema would be the result of an enhanced transcapillary filtration due to the low colloid osmotic pressure but with normal plasma–red blood cell ratio. Anæmic œdema[30] would develop as a result of increased transcapillary filtration due to an enlarged plasma section relative to the red blood cell section but with normal colloid osmotic pressure. In both cases the capacity of the red blood cells to remove water from the tissue fluid would have been exceeded. The final result would be influenced by the state of contraction of the capillaries, and this could be the explanation for the very puzzling fact that nephrotic œdema may be excreted without change of colloid osmotic pressure (ref. 31 and my observations), and, as it must be surmised, with an

adverse change of tissue pressure and extracapillary colloid osmotic pressure—the other forces that play a part in Starling's hypothesis.

The cases of severe chronic cor pulmonale with œdema that vanishes with treatment which improves the low arterial oxygenation and the carbonic dioxide retention, but otherwise has no direct effect, may represent an interference with the osmotic function of the red blood cells because of faulty gas exchange.

These are all examples of clinical facts hitherto unexplained. The demonstration of negative tissue pressure, by Guyton *et al.*[32], the fact that the joint cavities are kept 'dry', and Mannery's estimate[33] that the tissue fluid is normally only sufficient to cover the structures with a thin layer of tissue fluid, fit in well with the surplus of suction effect that the red blood cells might be able to generate. An effect would be self-limiting by the increase in surface tension forces in the tissue and the increase in colloid osmotic pressure of the tissue fluid that it would bring about.

Finally, the observation repeatedly made in perfusion experiments, that blood is superior to plasma in preventing œdema[34–36], and that oxygenated blood is better than deoxygenated[37], would seem less controversial[38–40] in the light of a red blood cell effect than it does now.

The argument and the examples presented here are not meant as a substitute for experimental scrutiny, as it is all too obvious that our present knowledge about the capillary circulation is too meagre to permit any solid deductions. It might, however, be worth while to take the suggested possibility into consideration in future work in the many fields where the capillary circulation plays a significant part.

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COMPARISON OF AN ATTENUATED AND VIRULENT LOUPING ILL STRAIN

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OUR work on the 'attenuated strain of louping ill virus' began in 1957 [1] during experiments on the transmission of tick-borne encephalitis viruses by milk of domestic animals. Besides the Czechoslovak strain *Hypr* of tick-borne encephalitis a virus strain labelled by the Instituto of Epidemiology and Microbiology in Prague as louping ill was included in our investigation so as to compare the properties of both strains. It was found that the strain *Hypr* of tick-borne encephalitis (TBE) when inoculated subcutaneously to sheep caused regular viræmia and excretion of virus into milk in large quantities (Table 1). After intracerebral infection it caused death 5–6 days later. In sheep infected with the louping ill strain, viræmia was of short duration and excretion of the virus by milk was observed only in two out of six animals (Table 2).

Therefore, we decided to investigate more carefully the properties of the aforementioned louping ill strain, which was originally obtained by Dr. Gallia, Institute of Epidemiology and Microbiology, Prague, and passed to our Instituto in 1956. Further, we shall call this strain 'attenuated louping ill strain'. For comparison, another louping ill strain was chosen isolated recently from Nature and kindly supplied by Dr. MacCallum, London. This strain was used in its second to fourth intracerebral passage on mice and will be called 'virulent louping ill strain'.

The pathogenicity of the two louping ill strains was examined in white mice from two breeds with higher (Děčín) and lower (Dobrá Voda) susceptibility, in suckling rats, hamsters, monkeys and sheep (Table 3).

The virulent louping ill strain was pathogenic after intracerebral inoculation for all animals listed. After intracerebral infection in sheep, it caused regular encephalitis and death.

The 'attenuated louping ill strain' killed mice both after intracerebral and peripheral inoculations; suckling rats and young hamsters died after intra-

Table 1. Results of Inoculating Sheep with Tick-borne Encephalitis Virus. *Hyps*

No. of sheep	LD_{50} inoculation	Route of inoculation	Clinical symptoms	Virus in blood and milk (days after infection) 1 2 3 4 5 6 7 8	Neutralization index†
45	$6{\cdot}66 \times 10^{3}$	subcutaneously	−	△ △ △ △ ○ ○ ○ ○	100
46	$6{\cdot}66 \times 10^{3}$	,,	−		1,000
868	$1{\cdot}04 \times 10^{4}$	,,	−		12,000
869	$1{\cdot}04 \times 10^{4}$	,,	+	△ △ △ ○ ○ ○ ○	126,000
38	$6{\cdot}66 \times 10^{3}$	,,	−		10,000
867	$1{\cdot}04 \times 10^{4}$	,,	−	△ ○ △ ○	251,000
1*	$6{\cdot}66 \times 10^{3}$	intracerebrally	+	−	Death after 6 days
10*	$6{\cdot}66 \times 10^{3}$	,,	+	△ △ △	6 days
50*	$6{\cdot}66 \times 10^{3}$	,,	+		5 days

* Lamb; △, isolation of virus from blood; ○, isolation of virus from milk; † neutralization index for mice inoculated intracerebrally.

Table 2. Results of Inoculating Sheep with Attenuated Louping Ill Virus

No. of sheep	LD_{50} inoculation	Route of inoculation	Clinical symptoms	Virus in blood and in milk (days after inoculation) 1 2 3 4 5 6 7 8	Virus in brain
23	$6{\cdot}66 \times 10^{3}$	Subcutaneously	−	− − − − − − − −	−
24	$6{\cdot}66 \times 10^{3}$	,,	−	− − − − − − − −	−
27*	$3{\cdot}33 \times 10^{3}$	,,	−	− − (○) − − − (△) ○	−
49*	$3{\cdot}33 \times 10^{3}$	,,	−	− − − − − − − −	−
5	$6{\cdot}66 \times 10^{3}$	,,	−	− − − − − − − −	−
15	$6{\cdot}66 \times 10^{3}$	,,	−	△ − − − − − − −	−
25†	$6{\cdot}66 \times 10^{3}$	intracerebrally	−	− − − − − − − −	−
26†	$6{\cdot}66 \times 10^{3}$	,,	−	− − − − − − − −	−
30†	$3{\cdot}33 \times 10^{3}$	,,	−	− − − − − − − −	−
31†	$3{\cdot}33 \times 10^{3}$	,,	−	− − − − − − − −	−

* Infected by ticks; △, virus in blood; ○, virus in milk; −, negative results; †, lamb.

Table 3. Experimental Pathogenicity of Attenuated and Virulent Louping Ill Virus

Animals	Route of inoculation	Virulent louping ill virus: Clinical symptoms	Death	− log. LD_{50}*	Encephalitis (histology)	Attenuated louping ill virus: Clinical symptoms	Death	− log. LD_{50}*	Encephalitis (histology)
Mice, 'Děčín' breed	intracerebrally	+	+	6·0	+	+	+	7·5	+
	subcutaneously	+	+	4·1	+	+	+	6·0	+
Mice, 'Dobrá Voda' breed	intracerebrally	+	+	5·5	+	+	+	6·6	+
	subcutaneously	+	+	4·0	+	+	+	6·0	+
Suckling rats	intracerebrally	+	+	5·0	+	+	+	7·0	−
Suckling hamsters	intracerebrally	+	+	−	+	+	−	−	−
Monkey	intracerebrally	+	0	−	+	0	0	−	0
Sheep	intracerebrally	+	+	−	+	0	0	−	×
	subcutaneously	±	0	−	±	0	0	−	0

+, Positive result; 0, negative result; ±, irregular result; −, not tested; ×, vascular changes only; *, in brain.

cerebral inoculation. It produced, however, no clinical symptoms or death in monkeys and sheep. Even after massive intracerebral inoculation with a 10 per cent suspension containing $10^{5.52}$ LD_{50}, no signs of illness occurred.

The titres for the two strains are shown in Table 3.

The differences in pathogenicity of the two louping ill strains led us to examine the course of infection in their closest and most susceptible natural host, namely, in sheep.

After infection with the virulent louping ill strain, elevation of temperature ensued 3–4 days later, reaching 41·7° C. On the fifth day tremor, ataxia and paralysis developed. Death occurred 5–7 days after inoculation. On section, a marked hyperæmia and small hæmorrhages were present in the brain and spinal cord. From animals killed at various intervals after inoculation nineteen tissue samples were taken for virological and morphological examinations. After intracerebral inoculation, no virus was present at the 24-hr. interval; 3 days after inoculation it was present only in tissues of the reticulo-endothelial system and in the central nervous system. At the same time, encephalitis could be demonstrated histologically. Five days after inoculation, virus could be demonstrated in high titres (up to 10^{6}) in brain both virologically and by the fluorescent antibody methods. Inflammatory lesions and damage of neurones were present.

After subcutaneous infection of sheep with the virulent strain of louping ill, a long-lasting viræmia developed, reaching considerable values. In tissues measurable amounts of virus were present not earlier than 3 days after inoculation and again in the lymph nodes and spleen. Five days after inoculation, virus was present in reticulo-endothelial tissues and also in the ganglia of the peripheral nervous system. Slight perivascular changes in the central nervous system 7 days after inoculation pointed to incipient invasion of the central nervous system, although no virus could be demonstrated virologically.

Under similar conditions, experiments were performed with the 'attenuated louping ill strain'. No rise in temperature occurred after intracerebral or subcutaneous inoculation even with a high dose of virus. Attempts to isolate virus from organs of these animals were unsuccessful. Histological examination of animals inoculated intracerebrally showed perivascular infiltrations, although no damage of nerve cells could be demonstrated, as was the case with the virulent strain. No viral antigen could be demonstrated in nerve cells with the method of fluorescent antibodies. Animals inoculated intracerebrally with normal mouse brain or with a suspension of attenuated louping ill virus inactivated at 56° C. for 1 hr., showed no histological changes at all.

To determine whether, in spite of these unusual pathogenic features, the 'attenuated louping ill strain'

really belongs to the tick-borne encephalitis group, the neutralizing capacity of sera against different tick-borne encephalitis viruses (Czechoslovak tick-borne encephalitis virus, virulent louping ill and 'attenuated louping ill strains') was tested with the 'attenuated louping ill virus'. The louping ill virus was neutralized in the intraperitoneal neutralization test by all three sera used.

To test the immunogenicity of the two louping ill strains, two sheep were inoculated subcutaneously with the virulent and two with the attenuated strains. Both viruses led to the formation of neutralizing antibodies, the neutralization index reaching values of more than 3 logarithms.

In a protection test, sheep were inoculated with a 10 per cent suspension of the attenuated louping ill strain. Ten and 14 days later, they were challenged with the virulent louping ill strain. Control animals which received only the virulent strain died 7 days after inoculation. Sheep inoculated first with the attenuated strain, remained well for the following 14 days of observation.

Preliminary results only have been reported here. Perhaps these findings could form a basis for a possible use of this strain for the preparation of a vaccine against viruses of the tick-borne encephalitis complex.

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TWO PHOTOCHEMICAL SYSTEMS IN PHOTOSYNTHESIS

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BY sensitive differential absorption spectroscopy it was demonstrated[1] that illumination causes oxidation of an *f*- or *c*-like cytochrome in *Porphyridium cruentum*. The action spectrum for cytochrome oxidation showed a maximum at 680 mμ, apparently due to chlorophyll *a*, and a much lower maximum at 560 mμ, probably due to phycoerythrin[2]. This was surprising, since light of 680 mμ is known to be far less efficient in bringing about photosynthesis and chlorophyll *a* fluorescence than equally intense light of 560 mμ (ref. 3, cf. ref. 4). From this, it followed that at least two photochemical pigment systems are present in *Porphyridium*. The system which is mainly responsible for the action spectrum of chlorophyll *a* fluorescence is called system 2. System 2 contains fluorescent chlorophyll *a* and a high proportion of phycobilins, mainly phycoerythrin; light quanta absorbed by phycoerythrin in this system are transferred to the fluorescent chlorophyll *a* and are thus photochemically active (cf. ref. 3). The other system, 1, contains non- or weakly fluorescent chlorophyll *a* and less phycobilins, and is active in cytochrome oxidation. We will assume that only these two pigment systems are present in *Porphyridium*; this assumption will prove sufficient for a satisfactory interpretation of our experiments.

It has also been observed[2] that the kinetics of cytochrome oxidation were different in light of 560 mμ from those in light of 680 mμ. This phenomenon shows that at least two pigment systems, which according to the preceding assumption must be the systems 1 and 2, interact in the cytochrome reaction. The kind of interaction is shown in Fig. 1. The decrease in absorption at its maximum, 420 mμ, which was shown to be a measure of the oxidation of the cytochrome, was recorded. The recorder tracing shows that actinic light of 680 mμ causes oxidation of the cytochrome; additional illumination with actinic light of 560 mμ causes a reduction of this cytochrome. Addition of the herbicide 3-(3,4-dichlorophenyl)-1,1-dimethylurea (DCMU) to the very low concentration of $1{\cdot}1 \times 10^{-6}$ *M* inhibited the reduction at 560 mμ; an oxidation is observed instead. A similar effect was observed in the presence of $4{\cdot}3 \times 10^{-3}$ *M* N-ethylurethane. The simplest interpretation of these experiments is that system 1, with a predominant activity at 680 mμ, directly or indirectly oxidizes, and that system 2, with predominant activity at 560 mμ, reduces the cytochrome; DCMU prevents system 2 in some way from reducing the cytochrome.

The action spectrum of cytochrome oxidation in the presence of DCMU or N-ethylurethane is shown in Fig. 2. According to the previous interpretation, this action spectrum should be equal to that of system 1.

It was found that the action spectrum of systems 1 and 2 varied for different cultures. We estimated the ratio of activities at 560 and 680 mμ to vary for system 2 between at least 2·4 and 6, and the corresponding ratio for system 1 from 0·8 to 1·2. The ratio for system 2 was calculated from earlier measurements[3,4].

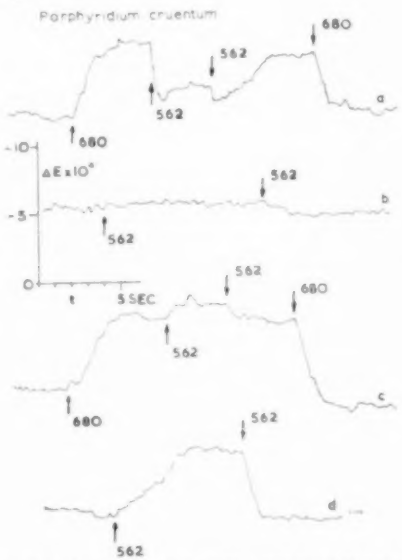

Fig. 1. Recorder tracings of absorption changes of *Porphyridium cruentum* at 420 mμ in the absence (*a*, *b*) and in the presence (*c*, *d*) of DCMU. Upward deflexions are decreases in absorption and reflect the oxidation of cytochrome. Upward and downward pointing arrows indicate the switching on and off of the actinic light. (The intensities are $4{\cdot}4 \times 10^{15}$ Einstein/(cm.^{2} sec.) at 680 mμ and $5{\cdot}3 \times 10^{15}$ Einstein/(cm.^{2} sec.) at 562 mμ.) Tracing (*a*) shows a reduction of the cytochrome by light of 562 mμ

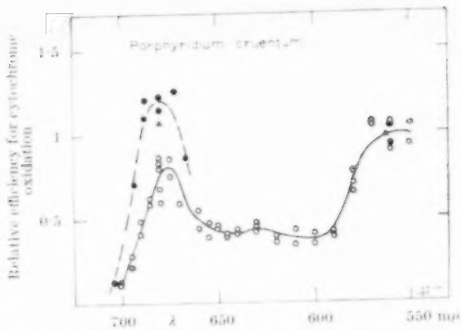

Fig. 2. Action spectrum for cytochrome oxidation in the presence of N-ethylurethane (open circles) and of DCMU (solid circles and triangles) for three different cultures of *Porphyridium cruentum*

Because of the approximate proportionality between the action spectrum of photosynthesis and that for excitation of chlorophyll *a* fluorescence, it had been concluded[2,3] that the pigment system responsible for the chlorophyll *a* fluorescence (system 2) was active in photosynthesis. The non- or weakly fluorescent chlorophyll *a* was believed to be inactive. However, the fact that both systems react with the same cytochrome indicates that system 1 also participates in photosynthesis and supplements in some way system 2. The relatively good quantum efficiency for cytochrome oxidation (about 5 quanta absorbed at 680 mμ per cytochrome molecule oxidized[2]) supports this view.

Further support for the hypothesis that systems 1 and 2 interact in photosynthesis was obtained from photosynthesis measurements by means of an oxygen polarograph, similar to one described recently[8]. The relative rates of photosynthesis calculated per equal number of incident quanta per sec., for light of 570 mμ and 680 mμ, were 83·5 and 20·6 (ratio, 4·0) and, with $2{\cdot}1 \times 10^{-2}$ *M* N-ethylurethane, for another sample of the same culture, 59·5 and 9·6 (ratio, 6·2). It is interesting to see that the percentage inhibition, which at a given wave-length is the same for various intensities, is smaller in actinic light of 570 mμ than in that of 680 mμ. This phenomenon was observed with both DCMU and N-ethylurethane with four different cultures. An experiment with DCMU gave a ratio 560/680 mμ of 7·0, as compared with a ratio of 4·4 without inhibitor.

When photosynthesis of unpoisoned *Porphyridium* was measured at 680 mμ with a background of strong light of 562 mμ, the rate of photosynthesis was found to be enhanced considerably (by a factor of 2). A similar enhancement effect has been observed for species of algae of different groups by Emerson and co-workers[7], and more recently by other authors, and has been called the 'Emerson effect'. The enhancement effect earlier observed[8,9] in *Porphyridium* occurred to a smaller extent and under conditions different from those reported here.

Our experiments can be interpreted as follows: In order to bring about photosynthesis, systems 1 and 2 must both be excited. If system 2 is strongly inhibited, the rate of photosynthesis, and thus the action spectrum of photosynthesis, will be mainly determined by system 2 at all wave-lengths. In uninhibited algae, however, system 2 is more active than system 1 at 560 mμ, and less active at 680 mμ. If the algae are illuminated with both wave-lengths simultaneously, then the rate of photosynthesis will be higher than the sum of the rates at each wave-length separately, because by simultaneous illumination the excess absorptions supplement each other.

The 'Emerson effect' has been observed for a variety of algae, belonging to different classes. This indicates that the scheme of Fig. 3, which summarizes and generalizes our hypothesis, applies also for other algae and probably for higher plants too.

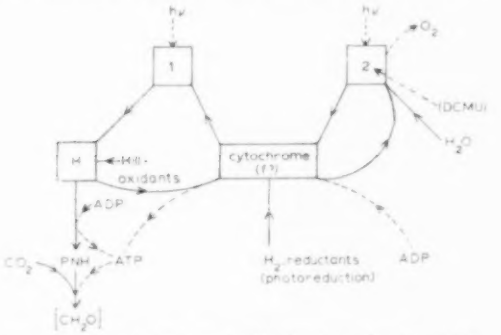

Fig. 3. Hypothetical scheme showing functions of systems 1 and 2 in photosynthesis

Further evidence for this scheme is as follows. DCMU, which strongly inhibits photosynthesis, does not inhibit the photoreduction of carbon dioxide with hydrogen gas in *Scenedesmus*[10] and the photoreduction of triphosphopyridine nucleotide (TPN) by spinach chloroplasts in the presence of ascorbic acid and a catalytic amount of 2,6-dichlorophenol indophenol[11]. This indicates that these photoreductions proceed via system 1 solely. The action spectrum for the reduction of phosphopyridine nucleotide (PN) in the blue alga *Anacystis nidulans* in the presence of DCMU was found to be proportional to the action spectrum for cytochrome oxidation, also measured in the presence of DCMU[12]. Thus reduction of PN is presumably closely linked to system 1.

The observation[13] that also the Hill reaction of *Chlorella* with quinone shows an 'Emerson effect', indicates that both systems 1 and 2 participate in the Hill reaction.

Our scheme is intended as a working hypothesis, which is certainly incomplete, and may require modification. At present it explains most experiments known to us in a simple and plausible way. A more detailed report is in preparation, in which we will discuss partly similar but less detailed and experimentally less supported hypotheses concerning the role of the photosynthetic pigments which have been proposed recently by other authors.

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WOOD-BORING ACTIVITY OF *LIMNORIA* (ISOPODA) IN RELATION TO OXYGEN TENSION

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CONFLICTING reports are found in the literature concerning the effect of pollution on the wood-boring activity of the marine isopod *Limnoria*. Some authors[1-3] consider it has a deleterious effect, others[4-7] that it has no effect, while Fraser[8] maintains that a moderate degree of pollution is beneficial to the borer. The confusion probably arises from the various forms the pollution can take, for example, chemical, oil or organic. The toxicity of chemical effluents will depend on their concentrations; but it was thought that organic pollution affected *Limnoria* to the degree by which it reduced the dissolved oxygen content through its decomposition. It was observed that *Limnoria* abandon their burrows in stagnant sea-water, and this reaction has been made the basis of an experiment to evaluate the effect of the oxygen tension on the boring activity. The possibility was also considered that changes in *p*H of the water, caused by the decomposition of organic matter on the wood, were responsible for the evacuation of the burrows.

The experimental procedure was as follows: a large piece of piling, showing about 260 sq. cm. of *Limnoria*-attacked surface, was scraped down to remove debris and attached organisms and rinsed several times in clean sea-water. The water-logged wood was immersed in sea-water which had previously been well aerated, and was allowed to stand for a period of five days. Initial measurements were made of the *p*H and oxygen tension of a sample of water taken from near the timber surface. These readings were repeated at intervals during the experiment. Immediately after each set of readings, the wood was taken from the water and all *Limnoria* on the surface were counted and removed. At the end of the experiment the wood was split open and all animals remaining in the wood were counted. Thus the original total population was known, and the percentage of animals leaving the wood at intervals was calculated. A correlation was then sought between these figures and the *p*H and oxygen tension records.

The oxygen tensions were measured by the Whitney syringe pipette method[9], which allowed a sample of water to be taken under the surface adjacent to the burrow entrances. Accurate measurements could not be made below an oxygen content of 0·5 per cent saturation. The readings are given as percentages of the oxygen present in saturated sea-water corrected for temperature and salinity, using the solubility tables of Truesdale *et al.*[10]. The *p*H values were estimated colorimetrically, using a B.D.H. small comparator with phenol red indicator. The salinity of the water was 35·8 per mille and its temperature during the experiment varied between 16° and 17° C.

The timber, which was taken from pine piling at Calshot Pier in Southampton Water, contained three species of *Limnoria*, namely, *L. lignorum* (Rathké), *L. quadripunctata* Holthuis and *L. tripunctata* Menzies. In order that any differences in behaviour could be assessed, the specific composition of a sample of 50 individuals was noted each time a group of *Limnoria* was removed from the wood.

The results of the experiment are given in Table 1. The rate at which *Limnoria* left the wood is compared with the *p*H and oxygen tension readings in Fig. 1. This shows that the desertion of the timber by *Limnoria* was accompanied by a progressive reduction in the oxygen content of the water. There was little variation in the *p*H (8·0–7·6) over the course of the experiment and this small change can have had little effect as *Limnoria* is said[11] to be tolerant of a *p*H range between 4·5 and 9·6. It is a reasonable assumption, therefore, that the exodus of the *Limnoria* was caused by the fall in oxygen tension. From these results an estimate can be made of the percentage saturation value which limits the boring activity.

The plots of the percentage of *Limnoria* leaving the wood fall on a sigmoid curve, the steep slope of which corresponds approximately to the time interval between 25 and 85 hr. During this period of maximum desertion, the oxygen tension fell from

Table 1. RATE AT WHICH *Limnoria* LEFT THE TIMBER UNDER REDUCED OXYGEN CONDITIONS
Each percentage shows the proportion of *Limnoria* which had left the timber since the beginning of the experiment

Time (hr. from beginning of experiment)	*p*H	O_2 tension (per cent saturation)	No. and progressive percentage of *Limnoria* leaving the timber: Combined species No.	Combined species per cent	*L. lignorum* No.	*L. lignorum* per cent	*L. quadripunctata* No.	*L. quadripunctata* per cent	*L. tripunctata* No.	*L. tripunctata* per cent
Zero	8·0	90·5	0	—	0	—	0	—	0	—
18·5	7·8	34·4	221	6·4	13	7·7	199	7·5	9	1·5
32·5	7·8	24·7	169	11·3	3	9·5	149	13·0	17	4·2
42·5	7·8	12·8	425	23·6	9	14·8	357	26·4	59	13·8
48·0	7·8	5·9	235	30·4	5	17·7	207	34·2	23	17·5
55·5	7·8	4·1	266	38·1	11	24·3	234	42·9	21	20·9
69·0	7·6	2·8	606	55·7	12	31·4	485	61·1	109	38·6
95·0	7·6	0·7	761	77·7	107	94·7	441	77·7	213	73·2
126·0	7·6	< 0·5	337	87·5	0	94·7	243	86·8	94	88·5
143·0	7·6	< 0·5	79	89·7	2	95·9	63	89·1	14	90·7
No. remaining in timber			354	(10·3)	7	(4·1)	290	(10·9)	57	(9·3)
No. initially in timber			3,453	(100·0)	169	(100·0)	2,668	(100·0)	616	(100·0)

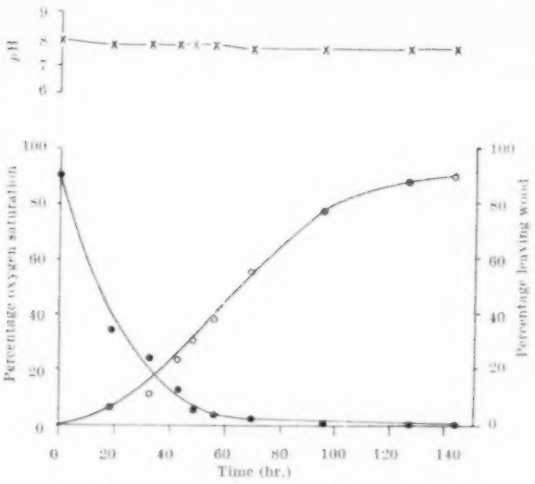

Fig. 1. Relation between the oxygen tension of sea-water and the rate at which *Limnoria* abandoned the timber
○, percentage of *Limnoria* leaving timber; ●, percentage oxygen saturation; ×, pH

about 17 to 1 per cent. Below about 17 per cent saturation, therefore, the amount of dissolved oxygen must have begun to exert a limiting effect on the boring activity. The actual values for the water within the burrows were probably somewhat less than those given above. These results show a considerable toleration of low oxygen conditions, for 50 per cent of the *Limnoria* had not left the wood at oxygen tensions as low as 3 or 4 per cent saturation, and even at the end of the experiment, when the oxygen content was too low to be measured, 10 per cent of the *Limnoria* still remained in the wood. There is no certainty, however, that these animals were still able to bore. It is difficult to assess a limiting value for the oxygen tension but it seems probable, from Fig. 1, that the critical value had been reached at 2 per cent saturation.

The figures for the separate species, derived from the analyses of samples each of 50 *Limnoria*, show a difference between *L. quadripunctata* and *L. tripunctata*. A higher proportion of the former species left their burrows earlier, and therefore at a higher oxygen tension, than was the case with *L. tripunctata*. However, the final percentage of either species remaining in the wood at the end of the experiment was the same. The more erratic rate of emergence of *L. lignorum* from the burrows may be an artefact, due to the small numbers of this species present in the total population. However, its behaviour resembled that of *L. tripunctata* in that the majority of the specimens did not leave the wood until very low oxygen conditions (less than 3 per cent saturation) obtained. It seems, therefore, that *L. quadripunctata* is more sensitive than the other species to low oxygen concentrations.

The conclusions of this experiment in relation to pollution apply to those cases in which the pollution causes a reduction in the oxygen tension of the water. It is suggested that if the oxygen dissolved in the water at the surface of submerged timber falls to a level below 2 per cent saturation, the boring activity of *Limnoria* within the wood will cease. This conclusion could have practical applications in problems of *Limnoria* infestations.

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THE EFFECT OF DEPTH OF TRANSPLANTING ON TILLERING AND SEED PRODUCTION IN WHEAT

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SEVERAL strand plants, namely members of the Gramineae, are known to thrive on wind-blown sand. These are *Agropyron junceum* L., *Elymus arenarius* L. and especially *Ammophila arenaria* Link. The latter species reacts favourably to periodical burial under fresh layers of sand by producing tall robust shoots from the lower leaf axils[1].

Pot experiments with transplanted *Ammophila* culms showed that increased depth of planting tended to produce more stout shoots, although the over-all yield was not greatly affected (Halwagy, unpublished work).

The present work aimed at exploring the possibility of a similar response in a cultivated member of the Gramineae. Wheat (*Triticum vulgare*) was chosen as the study material.

Culms of *Triticum vulgare* (Giza 139) were obtained from the University of Alexandria farm on February 23, 1957. They had been grown from seed on November 17, 1956. The culms were cut back to a uniform length of 50 cm. Of this, 8–10 cm. had been underground, consisting of a few internodes and carrying buds at the nodes. Culms were well mixed before being transplanted in 30-cm. pots, in clayey loam. Each pot had 25 culms; culms and pots being allotted to treatments at random. The pots were arranged in a Latin square of 5 replicates and 5 treatments. The 5 treatments were: culms transplanted at a

Table 1

Treatment	Total No. of shoots	No. of flowering shoots	Dry weight of shoots (gm.)	Dry weight of spikes (gm.)	Dry weight of crop (shoots + spikes) (gm.)
A (transplanted 10 cm. deep)	76 ± 10·02	15 ± 7·64	97·4 ± 26·52	25·59 ± 16·71	123·0 ± 40·74
B (transplanted 15 cm. deep)	92 ± 10·02	52 ± 7·64	185·6 ± 26·52	86·58 ± 16·71	272·2 ± 40·74
C (transplanted 20 cm. deep)	48 ± 10·02	12 ± 7·64	58·7 ± 26·52	19·05 ± 16·71	77·7 ± 40·74
D (transplanted 25 cm. deep)	11 ± 10·02	5 ± 7·64	13·3 ± 26·52	5·48 ± 16·71	18·7 ± 40·74
E (transplanted 28 cm. deep)	16 ± 10·02	10 ± 7·64	16·6 ± 26·52	7·59 ± 16·71	23·9 ± 40·74

depth of 10, 15, 20, 25 and 28 cm. below the soil surface.

On May 13, 1957, the height of all new shoots was measured. On July 4, 1957, the crop was harvested by clipping at soil-level. The following quantitative estimates were made: the total number of shoots, the number of flowering shoots, dry weight of shoots (oven-dried at 105° C.), dry weight of spikes (excluding the spike-bearing stalks, oven-dried at 105° C.) and the mean shoot weight. The results were analysed statistically and the 5 per cent level of significance adopted.

The effect of the depth of transplanting on the yield, as measured by different characteristics, is shown in Fig. 1. The analysis of variance (Table 1) showed that transplanting at a depth of 15 cm. produced a larger number of shoots than all other treatments, transplanting 10 cm. deep excepted. Further, that the number of flowering shoots, dry weight of shoots, spikes and total weight of crop were significantly greater in culms transplanted 15 cm. deep than in any other treatment. The better growth is due to the production of more shoots, vegetative and flowering, rather than producing heavier individual shoots.

The reaction of transplanted wheat culms to various depths of planting, as revealed by this work, is at variance with that of *Ammophila*. For wheat, the optimum depth appears to be 15 cm. In *Ammophila*, the quality rather than the quantity of new growth was influenced by the depth of transplanting. Increased depth (between 10 and 25 cm.) caused a slight increase in the over-all weight of shoots, but had a more pronounced effect on the mean shoot weight. Culms planted at greater depths produced fewer but taller and stouter shoots.

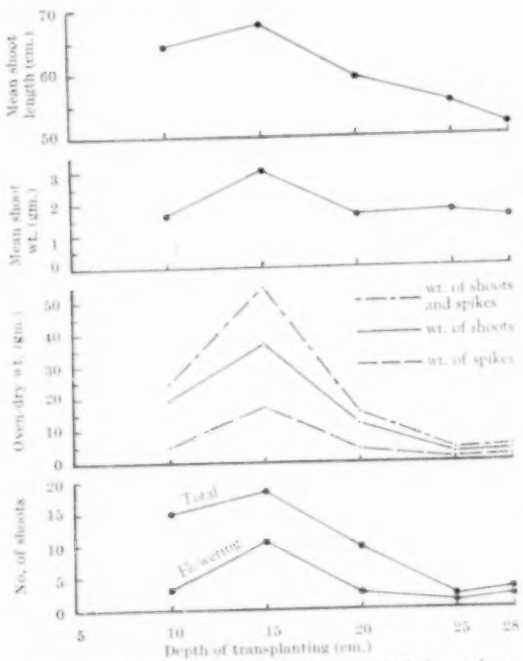

Fig. 1. Effect of depth of transplanting on yield of wheat culms

The nature of the stimulus is not fully understood. It seems likely that by increasing the depth of burial of wheat culms from 10 to 15 cm. the buds are pushed a few centimetres in the soil, where the temperature is more or less constant and large fluctuations in temperature are thus avoided. Moreover, deeper buds become less subject to desiccation when the top centimetres of the soil dry out. These buds will therefore have a better chance of tillering, than the more shallowly placed ones nearer the soil surface.

It is not clear, however, why further burial (at 20, 25 and 28 cm.) does not induce still better tillering. It should be recalled that the yield data are based on the aerial portion of the crop, so that the number and weight of shoots recorded refer to those shoots which emerged above the soil surface. It might have been desirable to investigate the possibility of production, from the deeply buried buds, of tillers which failed to appear above the soil surface and were therefore not taken into consideration.

The results of this experiment are more suggestive than conclusive, and may well prove rewarding if further work is carried out along similar lines. Also, the economic implications of the problem have not been considered. It should be noted that in the field, the usual depth of the underground part of the culm is 8–10 cm. It has been shown that better vegetative growth and seed production may be induced by burying the culms to a depth of 15 cm. Before the advantages of these results are utilized, it is necessary to find out the effect of the mere pulling out and transplanting of wheat culms. Comparison must be made in the field, between the yield of plots on which wheat culms have been pulled and later transplanted 15 cm. deep, and control plots. It is very probable that pulling has an adverse effect on the subsequent growth and seeding of wheat culms, so that any gain in yield obtained through transplanting at a depth of 15 cm. will be counterbalanced by this inimical effect and the additional cost of labour.

Deep burial of seed at the time of sowing may seem an easier and more practicable alternative. But the limitations of this method are obvious since seedlings produced from seeds which had been sown too deeply will fail to emerge above the soil surface.

I am indebted to Prof. A. H. Nasr for various working facilities during the course of this work and to Prof. A. el Khishin for providing wheat culms. Thanks are also due to Dr. S. Tolba and Dr. S. Nasr for statistical advice.

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SEX AND STRAIN DIFFERENCES IN ELECTROSHOCK CONVULSIONS OF THE RAT

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OUR objectives were to determine whether differences in the threshold and pattern of electroshock seizures exist between male and female, and maze-bright and maze-dull rats.

Our interest in this problem developed from the following considerations: (1) Woolley and Timiras[1] have shown that the administration of various sex steroids to rats alters brain excitability as assessed by the electroshock seizure threshold test. The striking excitatory action of œstradiol suggested that female rats might have a lower convulsive threshold than males. (2) Rosenzweig *et al.*[2] have demonstrated that in rats selectively bred for differences in maze-learning ability, the superior learners (S_1 strain) have a higher brain acetylcholine (ACh) content and cholinesterase (ChE) activity than the inferior learners (S_2 strain). They have proposed that the level of central ACh–ChE activity is related to efficiency of neural transmission and of learning. This, together with reports[3] that drugs which lower the convulsive threshold also increase ChE activity in some parts of the cat brain, and with the finding[4] that subconvulsive doses of central excitatory drugs increase the learning ability of the rat, suggested that the S_1 strain might have lower convulsive thresholds than the S_2 strain.

In the present work male and female S_1 and S_2 rats, 125 days of age, were used. Electroshock seizures were produced with the apparatus described in ref. 5; this apparatus has a constant current circuit and can be pre-set to give the desired value of current independently of the resistance of the animal. The electroshock seizure threshold (EST) is defined as the minimal amount of alternating current in milliamperes delivered through corneal electrodes for 0·2 sec. which will elicit a barely detectable clonic convulsion of the ears, jaws and forepaws without loss of equilibrium. A lower threshold is assumed to indicate greater brain excitability.

In Table 1 are shown the EST values for the four sub-groups. In both strains, female rats have a significantly lower value than males. For both sexes, the S_1 rats have a lower EST than the S_2. (The P-values in the table are based on t-tests.) These sex and strain differences are what we expected.

Table 1. ELECTROSHOCK SEIZURE THRESHOLD DIFFERENCES IN MALE AND FEMALE MAZE-BRIGHT AND MAZE-DULL RATS

Strain of Rats*	$\bar{x}$ and σ of electroshock seizure thresholds (m.amp.)		Male vs. female P
	Male	Female	
Maze-bright (S_1)	23·41 ± 0·23	21·15 ± 0·20	< 0·01
Maze-dull (S_2)	24·32 ± 0·33	22·02 ± 0·27	< 0·01
S_1 vs. S_2 P	< 0·05	< 0·02	

* Eighteen rats were used in each of the four sub-groups, for a total of 72; all were about 125 days old.

Because the females were lighter than the males, it was desirable to determine whether EST was related to body weight. Therefore, correlations between body weight and EST were determined for each sex-strain sub-group separately and were then combined by Snedecor's method to give an average correlation. The following product–moment correlation coefficients were found: S_1 ♂, 0·76; S_1 ♀, 0·15; S_2 ♂, 0·51; S_2 ♀, 0·46; average 0·47 ($P < 0·01$). These positive correlations might be explained by either or both of two hypotheses: (1) variations in EST are consequences of the influence of body mass on current spread, and thus on current density in the brain. Therefore, the heavier the animal the greater the current that must be applied to elicit a seizure; (2) body weight and EST are independent expressions of the hormonal and metabolic balance of the animal.

To obtain further information on the effects of tissue mass on current density in the brain, we examined the correlation between brain weight and EST for the various sub-groups. These correlations ranged from − 0·12 to 0·01, none being significantly greater than zero. This may be interpreted as inconsistent with the 'tissue mass' hypothesis. Also, contrary to this hypothesis, is the fact that, although the S_1 and S_2 strains of rats differed significantly in EST, their body weights were equal.

It is known that œstradiol decreases body weight and EST. In support of the 'metabolic' hypothesis is the finding[6] that œstradiol can lower EST before body weight is decreased.

Although we tend to interpret the covariance of body weight and EST as reflecting two relatively independent effects of the hormonal state of the animal, we cannot eliminate completely the 'tissue mass' hypothesis. However, in our second test of brain activity, the maximal electroshock seizure (MES) pattern, the response to the supramaximal stimulus, is independent of current density, as demonstrated in ref. 7.

A maximal electroshock seizure consists of both tonic and clonic components, and in the rat the tonic phase is divided into tonic flexion followed by tonic extension of the limbs. The tonic extensor phase represents the maximal seizure activity of which the nervous system is capable, and its duration is taken as a measure of the spread or reverberation of impulses involved in convulsions. The duration of tonic flexion is proportional to the intensity of the inhibitory state which must be overcome before appearance of the tonic extension. Thus, the longer the tonic extension and/or the shorter the tonic flexion the greater the convulsability.

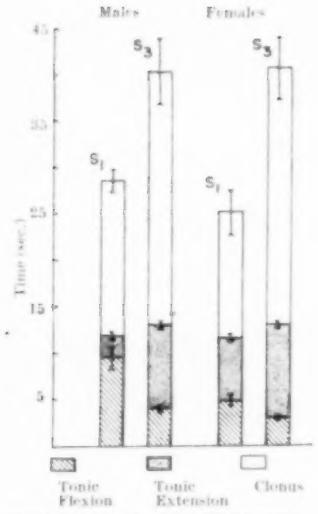

Fig. 1. Maximal electroshock seizure (MES) patterns in male and female maze-bright (S_1) and maze-dull (S_3) rats following a shock of 150 m.amp. for 0·2 sec. Eighteen rats were used in each of the four sub-groups, for a total of 72 rats; all were about 125 days old. Vertical bracketed lines show standard errors of the means for durations of each phase

The MES patterns for the different groups are given in Fig. 1. Again strain and sex differences were observed. 72 per cent of the S_3 males and 8 per cent of the S_1 females failed to exhibit tonic extension, whereas all the S_3 rats showed this phase. Both S_1 males and females showed significantly shorter total tonic and tonic extensor phases and significantly longer tonic flexor phase than the S_3. Duration of clonus was shorter in the S_1 strain than in the S_3.

Thus the maze-bright animals have a seizure pattern which suggests a lesser reverberation of impulses in the brain as compared with the maze-dull, although excitation occurs more readily in the maze-bright. This interpretation is in accord with conclusions[7] derived from investigations of behaviour of the S_1 and S_3 strains.

In both strains the males have a significantly shorter extension and longer flexion than the females. This sex difference can be ascribed to oestradiol, which has been shown[7] to lengthen tonic extension and shorten tonic flexion. Both the longer tonic extensor phase and the lower EST of the females support the view that they have a greater convulsability than males.

In conclusion, it seems to us that female rats have a greater convulsability than males, and both male and female rats of a maze-bright strain have lower seizure thresholds and shorter extensor phases during maximal seizures than maze-dull rats. It is suggested that these sex and strain differences are due to differences in hormonal balance (sex steroids) and brain chemistry (acetylcholine-cholinesterase levels).

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* U.S. Public Health Service predoctoral fellow.

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EFFECT OF *STAPHYLOCOCCI* ON LEUCOCYTE PYRIDINE NUCLEOTIDES

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THE presence of a normally inactive diphosphopyridine nucleotide (DPN) pyrophosphatase in *Staphylococcus aureus* has been shown[1] recently. The presence of this enzyme can be demonstrated in whole organisms or in sonic extracts only after certain manipulations such as heat treatment. Because in some circumstances *Staphylococci* may survive in leucocytes after phagocytosis[2], the possibility was entertained that intraleucocytic activation of this staphylococcal enzyme might decrease the pyridine nucleotide-level of the white cell sufficiently to interfere with its metabolism and with its eventual killing of the engulfed micro-organisms.

Changes in glycolysis, and in the monophosphate shunt, as well as in the electron transport system (all involving some pyridine nucleotide-linked reactions) have been reported as occurring in association with phagocytosis. Specifically, studies employing inert polystyrene particles as the foreign material have shown, during the phagocytic event, rather striking metabolic changes, such as increased oxygen uptake, increased lactate production, and increased activity of the monophosphate shunt as evidenced by an increased appearance of C-1 of glucose as carbon dioxide relative to C-6 of glucose[3]. The importance of glycolysis in the successful phagocytosis of heat-killed yeast cells by guinea pig polymorphonuclear leucocytes was further shown in the work of Fisher and Ginsberg[4]. They demonstrated reduced phagocytosis by polymorphonuclear leucocytes which had previously been allowed to react with influenza virus. However, their evidence suggested that the influenza-induced block in metabolism that resulted in decreased phagocytosis was probably at the glucose-6-phosphate to fructose-6-phosphate step.

Studies of oxygen uptake by leucocytes that had phagocytosed heat-killed *Staphylococci* have shown an increased uptake with a coagulase-negative strain of *Staphylococcus epidermidis* and decreased uptake by a coagulase-positive strain of *Staphylococcus*[5]. Similar investigations with viable coagulase-positive *Staphylococci* by the same workers have shown increased uptake of oxygen with one strain

and decreased uptake with a second strain. This work, particularly the decreased uptake of oxygen by white cells which had phagocytosed heat-killed coagulase-positive *Staphylococci*, suggested the possibility that the 'heat-activated' DPN pyrophosphatase of the micro-organism might have been active within the leucocyte, since DPN has a well-established role in electron transport. To study possible evidence for activation within the white cell of the normally inhibited DPN pyrophosphatase of *Staphylococcus aureus*, direct measurements of leucocytic pyridine nucleotides following interaction with various types of bacteria were undertaken.

In the work to be described, the polymorphonuclear leucocytes were prepared from exudates produced by the intraperitoneal injection of a sterile 12 per cent solution of neutralized sodium caseinate. The method of collection with heparinized saline, centrifugation, and washing was essentially that described by Sbarra and Karnovsky[2]. Cells were suspended in a Krebs-Ringer phosphate medium buffered at *p*H 7·4. Cells were enumerated in an improved Neubauer chamber, and there was regularly less than 1 per cent contamination with red blood cells. About 85 per cent of the white blood cells were polymorphonuclear leucocytes. The bacteria used were 16-hr. cultures grown with aeration in 2 per cent trypticase broth, except the *Streptococci*, which were grown under relatively anaerobic conditions in the medium of Bernheimer[6]. The number of viable organisms was established by colony counts. The bacteria were then centrifuged and washed twice in 0·9 per cent potassium chloride. Afterwards, they were thoroughly dispersed and suspended in either 0·9 per cent potassium chloride solution or in Krebs-Ringer phosphate buffer adjusted to *p*H 7·4. Incubation mixtures consisted of approximately 4×10^8 white blood cells, fresh guinea pig serum in a final concentration of 20 per cent, glucose (28 μmoles), and *Staphylococci* at average multiplicities of 2, 5, 10, 25, or 50 per white blood cell, all in a final volume of 6 ml. The mixtures, in polyethylene tubes, were shaken at 90 cycles/min. in 37° C. water-bath. In later experiments, incubation mixtures of 3 ml. volumes in small silicone-treated Erlenmeyer flasks were shaken under the same conditions. All experiments were carried out aerobically for 40 min. At the conclusion of the experiment the contents of the flasks were chilled, transferred to polyethylene tubes, and centrifuged in the cold at 11,000 *g*. The sedimented cells were then extracted with 5 per cent trichloroacetic acid and analysed for DPN by the methyl ethyl ketone fluorescence method[7]. For the estimation of the reduced form of DPN and TPN, hot 0·1 *N* sodium carbonate extracts were prepared[7].

The DPN content of freshly isolated guinea pig leucocytes was found to be 7·82 ± 0·38 μgm./10^8 white cells (20 determinations). The value for total pyridine nucleotides, that is, including the oxidized and reduced forms of both TPN and DPN, was 14·56 μgm./10^8 white cells. A somewhat lower value (9·22 μgm./10^8 white blood cells) for total pyridine nucleotides of human leucocytes has previously been reported[8].

Within three minutes of interaction with an average multiplicity of fifty viable *Staphylococci* (var. *aureus*, strain No. 241) per leucocyte, the white cell DPN-level began to decrease and continued to decrease over the first 15 min. of incubation (Fig. 1). After this time, for as long as 1 hr. the levels remained stationary. At this same average multiplicity even more striking decreases in the leucocyte DPN-level were produced when older cultures of *Staphylococci* were used. As can be seen in Fig. 2, cells well along in the stationary phase of growth (14–36 hr.) were more effective in lowering the DPN-levels than cells collected in the logarithmic phase of growth. That this enhancement of loss of DPN was not due to an increase in activity of the 'heat-activated' DPN pyrophosphatase of the organism can also be seen in Fig. 2. There was no significant variation in the specific activity of sonic extracts of *Staphylococcus aureus* No. 241 in cells harvested between ten and thirty-six hours of growth. Similar decreases in leucocyte DPNH and TPNH were observed in comparable experiments. The normal level of TPN in the cells was so low as to make measurements of change in its level subject to question.

In order to ascertain whether the decrease of DPN in the white cells was due to intracellular destruction or 'leakage' from the white cells, attempts were made to determine if DPN could be recovered from the medium after 40 min. of interaction of *Staphylococci* with leucocytes. None was recovered following lyophilization of the medium under conditions in which 5 μgm. of added DPN could readily be detected. However, inasmuch as intact guinea pig leucocytes have a potent DPNase which rapidly cleaves exogenous DPN, this experiment has not ruled out the possibility of DPN leakage and subsequent cleavage.

To evaluate further any possible role of the 'heat-activated' DPN pyrophosphatase of *Staphylococcus aureus* in the decrease in pyridine nucleotides of white blood cells, experiments were carried out with boiled *Staphylococci* (pyrophosphatase fully activated) at an average multiplicity of 50 per leucocyte. The decrease with boiled *Staphylococci* proved to be only about 60 per cent of that obtained with unboiled organisms. Although the original

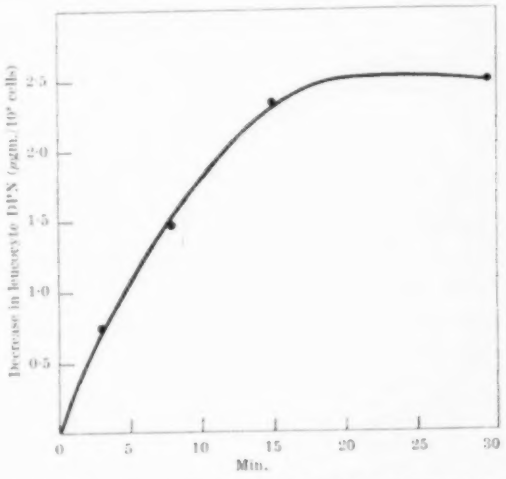

Fig. 1. Time-course of loss of DPN in white cells exposed to *Staphylococcus aureus* strain No. 241, at an average multiplicity of 50 *Staphylococci* per leucocyte. Time is in minutes after the addition of *Staphylococci* to white cell suspension in Krebs-Ringer phosphate solution containing 20 per cent fresh guinea pig serum and 28 μ mol. of glucose in a final volume of 6 ml.

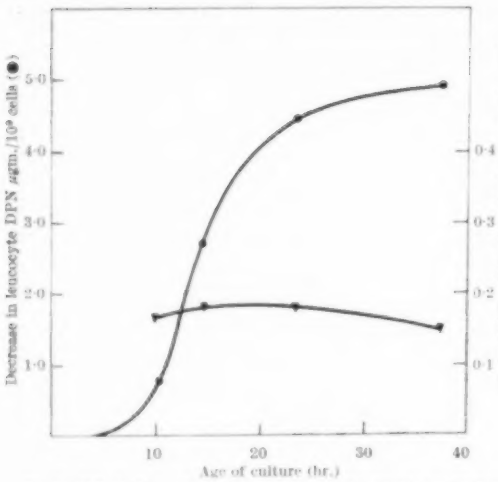

Fig. 2. Effect of age of *Staphylococci* (strain No. 241) in producing DPN decrease in white blood cells (average multiplicity of fifty). ● decrease in leucocyte DPN-levels induced by *Staphylococci* grown for varying number of hours; ▼, specific activity of 'heat-activated' DPN pyrophosphatase obtained from *Staphylococci* grown for varying number of hours

observations were made at high multiplicities (50), significant effects were noted with boiled and unboiled organisms at multiplicities of 10 and 25 (Table 1). It became possible to demonstrate decreases in leucocyte DPN-levels with multiplicities as low as 2 or 5 when incubation was carried out in siliconized flasks in which mixing was more efficient than in polyethylene tubes. Under these conditions, about 75 per cent of the white cells contained *Staphylococci* on stained smear.

Of five strains of coagulase-positive *Staphylococcus aureus*, all possessing the 'heat-activated' DPN pyrophosphatase, four produced distinct drops in the DPN content of leucocytes, but one strain (No. 754) did not (Table 2). One strain of *Staphylococcus albus* possessing the enzyme produced a decrease in DPN content, whereas two other strains lacking the enzyme failed to do so. The number of strains tested is too small as yet to draw any general conclusions.

The loss of pyridine nucleotides on interaction with *Staphylococci* is not a non-specific one resulting from interaction of any bacterium with leucocytes, as can be seen in Table 2. Three different strains of *Escherichia coli* did not lower the DPN-level of leucocytes. These organisms had no DPNase or DPN pyrophosphatase. Two strains of *B. subtilis* similarly had no effect, one of these, strain 'Brandeis' (kindly supplied by Prof. N. O. Kaplan), having a

Table 1. Effect of Number of *Staphylococci* and Method of Incubation on Leucocyte DPN-Levels

Average multiplicity	Per cent decrease in white blood cell DPN-levels		
	Unboiled*	Boiled†	Improved shaking (unboiled)‡
2	—	—	8·5
5	0	—	8
10	11	8	20
25	16	20	30
50	42	28	44·5

* *Staphylococci* not heated; shaken in polyethylene tubes.
† *Staphylococci* heated at 100° C. for 1 min.; shaken in polyethylene tubes.
‡ *Staphylococci* not heated; shaken in siliconized Erlenmeyer flasks.

Table 2. Effect of Various Bacteria* on Leucocyte DPN-Levels

Organism	'Heat-activated' DPN pyrophosphatase†	Per cent decrease in leucocyte DPN-level
Staph. aureus No. 241	+	30
" " No. 9196	+	24
" " No. 754	+	0
" " No. 9894	+	40
" " No. 193	+	10
Staph. albus No. 410	−	0
" " No. 331	−	0
" " No. 32	+	24
	Any type of DPN-cleaving enzyme†	Per cent decrease in leucocyte DPN-level
E. coli Strain *B*	−	0
" " Strain No. 93	−	0
" " Strain *X*	−	0
B. subtilis Strain 'MGH'	not tested	0
" " Strain 'Brandeis'	+	0
Proteus vulgaris (ATCC No. 9484)	+	0
Beta haemolytic *Streptococcus* No. 29	+	57
" " " No. 30	+	76

* Average multiplicity of fifty bacteria per leucocyte.
† +, present strain; −, absent in strain.

'heat-activated' DPNase. *Proteus vulgaris* (ATCC No. 9484) had a DPN pyrophosphatase which was not 'heat-activated', but it failed to cause a drop in DPN-levels. Both strains of group A *Streptococci* tested produced profound drops in white blood cell DPN-levels. It is of interest to note that strain No. 30 that caused the greater decrease did not produce the extracellular enzyme DPNase, whereas strain No. 29 produced large amounts of this enzyme. Thus, it would appear that the presence of a DPN-cleaving enzyme in a micro-organism is not necessarily correlated with its ability to induce DPN loss in leucocytes. Bernheimer *et al.* have shown a rather striking correlation between DPNase production and leucotoxicity of streptococcal strains. However, they were unable to demonstrate injury to the leucocytes by a purified preparation of the extracellular DPNase. However, this did not eliminate the possibility that DPNase might be responsible for the leucotoxicity, since it was not known whether the enzyme had actually penetrated into the leucocytes.

The significance of the loss of DPN in white blood cells initiated by *Staphylococci* and its possible relation to the virulence of the organism remains to be elucidated. Work on the survival of intracellular *Staphylococci* in such depleted white blood cells as well as further work on uptake of oxygen, etc., should help to elucidate the significance of this biochemical lesion.

This investigation was supported (in part) by a U.S. Public Health Service research grant (*E*-1884) from the National Institute of Allergy and Infectious Diseases, U.S. Public Health Service.

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LETTERS TO THE EDITORS

RADIOASTRONOMY

A New Determination of the Solar Parallax by Means of Radar Echoes from Venus

DURING the recent close approach of Venus the Jodrell Bank radio telescope has been used to obtain radar echoes from the planet. The radar equipment, which operated at a frequency of 408 Mc./s., had a peak-power of 60 kW. and gave 30-m.sec. pulses at one pulse per second. The transmitter and receiver were operated alternately for periods of approximately five minutes, the light-time to Venus and back. To eliminate fading caused by Faraday rotation of the line of polarization of the signals in the Earth's ionosphere, an aerial system transmitting right circular polarization and receiving left circular was used. This was achieved by means of a feed aerial consisting of crossed coplanar dipoles and reflectors fed in quadrature from a hybrid ring, which also provided 40 db. of isolation between the receiver and transmitter. An electron-beam parametric amplifier (Adler tube) with a noise figure of 2 db. formed the input to the receiver.

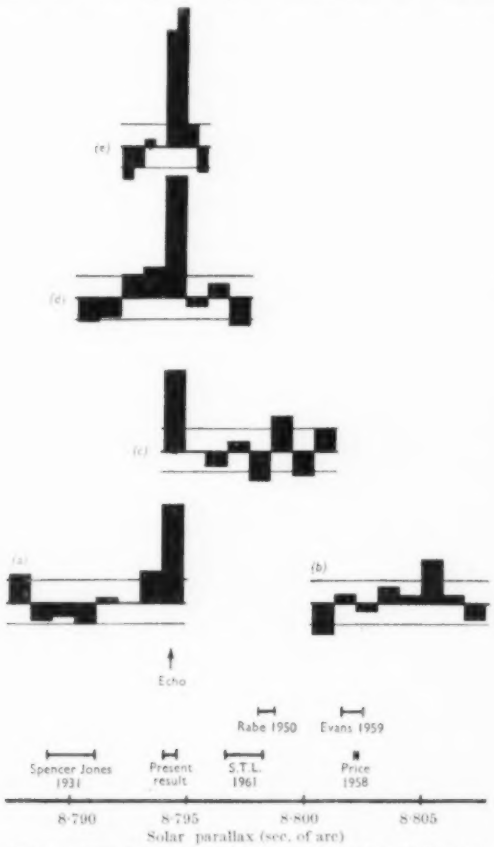

Fig. 1. Some recent determinations of the solar parallax are shown in relation to the present result. At (*a*), (*b*), (*c*) and (*d*) are shown histograms representing deviations from the mean of the eight integrator channels after twenty 5-min. periods of integration. The fine lines in each case represent one standard deviation. The range of Venus assumed on each occasion corresponded to the value of the solar parallax below the centre of each histogram; the echo always stayed in the channel corresponding to the present value. At (*e*) is shown the effect of halving the integrator channel width: the echo now divides equally between the two channels, confirming its central position

As the signal to noise ratio was expected to be less than unity a real-time integrator was used to detect the echo. The output of the final intermediate frequency amplifier, which had a band-width of 67 c./s., was applied to a linear detector; a variable frequency pulse output was then produced, linearly dependent in frequency on the detected voltage. The integrator sampled this pulse output at eight adjacent positions on the time base, each sampling period being 30 m.sec. The outputs from corresponding sampling periods on successive sweeps were counted in eight separate counting channels. Thus if only noise is present the counts in the eight channels will show random fluctuations about a mean, but if an echo is present the count in one channel will show a significant rise from the mean.

During the observations the range of Venus was changing by as much as a sampling period within a few minutes, so an automatic system was employed to alter the position of the sampling channels to keep the echo always within one channel. This system was accurate to within ± 2 m.sec. The Doppler shift of the returned signals was changing by an amount equal to the receiver band-width every few minutes, due to the rate of change of the relative line of sight velocity, and therefore the receiver was tuned manually to keep it within ± 3 c./s. of the predicted frequency. The whole spread of likely values of range was covered by three different settings of the sampling channels. Echoes were first detected on April 8, as soon as the equipment was operating correctly, and continued to be detected until observations ceased on April 25.

Fig. 1 shows some of the results, together with a chart of some other recent determinations of the astronomical unit, the values corresponding to the possible ranges of Venus explored. Each of the sections *a*, *b*, *c* and *d* shows the result of integrating for 20 receive periods assuming the value of the astronomical unit below the centre of the integration channel system. The lines on each side of the means represent one standard deviation. Also shown at *e* is the result of halving the sampling period in order to confirm the position of the echo more precisely; it will be seen that the echo is now divided equally to within a standard deviation between channels 3 and 4. The present result lies about half-way between the values of Rabe[1] and Spencer Jones[2], and is significantly lower than the recent Space Technology Laboratories[3] value.

Our result is:

Light-time for one A.U. = 499·011 ± 0·017 sec.

or

Solar parallax = 8·7943 ± 0·0003 sec. of arc

The computations of azimuth, elevation, range and Doppler shift needed for this work were made on the *Mercury* Computer in the University of Manchester. They were based on the *Astronomical Ephemeris* and the following values of constants were assumed:

Velocity of light	299,792·5 km./sec.
Equatorial radius of Earth	6,378·388 km.
Jodrell Bank radius of Earth	6,365 km.
Radius of Venus (ref. 4)	6,200 km.

The most likely cause of systematic error in the result is uncertainty as to the distance of the reflecting

surface from the centre of Venus; it has been assumed that this is the same as the planet's radius. However, if the effective reflecting surface were closer to the centre by 7 per cent it would only make an increase of one part in 10^3 in the above value for the parallax, so that such an effect would be small compared with the limits of error.

A previous attempt to determine the solar parallax was made at Jodrell Bank during the close approach of Venus in September 1959[5]. After 350 receive periods—equivalent to 58¾ hr. of integration—a value of the solar parallax of 8·8020 sec. of arc was determined on the basis of an echo of 2½ standard deviations. This agreed with the Millstone Hill value obtained in 1958[6], but there was an 8 per cent chance that noise alone produced the rise in the counter channel which would appear to be a probable explanation of these earlier results.

A fuller account of this work, together with a discussion of the radio albedo of Venus, will be reported elsewhere when the tape recordings made during the observations have been analysed.

We wish to thank Sir Bernard Lovell for his interest and encouragement. Our technical assistant, A. C. Prior, designed and constructed the automatic ranging circuits and gave valuable assistance at all stages of the programme. This work was supported in part by United States Air Force Contract No. *AF*61 (052)–172.

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ASTROPHYSICS

Observations of Satellite 1960 ζ1, and a Comparison with Satellite 1958 δ1

Since July, 1960, I have made observations of satellite 1960 ζ1 (*Midas* 2), as an exercise in prediction and visual tracking, and to study the damping of its spin. The following data and comments may be of interest to those engaged in precise analysis.

This satellite has given characteristic flashes, which are sharply defined when the satellite is between the Sun and the observer. This is in keeping with the now familiar experience that in 'crescent' illumination, the intensity of sunlight reflected from a satellite is most sensitive to change of profile, and superimposed specular reflexions. *Midas* 2 is normally a magnitude +3 object at close range, with infrequent flashes to magnitude +1; while at long range it is very much fainter.

Table 1 contains the data from my observations at this location, 34° 43′ S., 138° 42′ E. Timing the flashes by a simple stop-watch and binocular technique, the interval T containing N flash cycles can be determined usually to within 1 sec. The two observations made at long range, and therefore smaller angular velocity of transit, suggest a slight reduction of the observed flash period. It may be tentatively assumed that the cylinder is rotating in a direct sense about a transverse axis.

Table 1. Flash Period of Satellite 1960 ζ1, observed from Elizabeth, South Australia

Time of observation S.A. time	G.M.T.	Interval T (sec. ± 1)	No. of flash cycles N	Mean flash period (sec. ± $1/N$)	Approximate orientation
1960					
July 18.781	18.385	27·0	5	5·40	65° N.N.E.
Oct. 21.826	21.430	31·6	5	6·32	60° N.N.E.
Oct. 22.808	22.412	38·7	6	6·45	60° N.
Nov. 23.128	22.732	33·8	5	6·75	50° N.N.E.
Dec. 7.868	7.472	13·8	2	6·9	60° N.N.E.
Dec. 8.851	8.455	34·5	5	6·90	60° N.N.E.
Dec. 9.833	9.437	96·2	14	6·87	55° N.E.→E.
1961					
Jan. 9.157	8.761	22·0	3	7·3	55° N.E.
Jan. 10.140	9.744	36·0	5	7·20	55° N.N.E.
		43·0	6	7·17	45° N.E.→E.

If the 'tumbling' period ($\frac{1}{2}P$) can be stated closely by the relation: $\frac{1}{2}P = T/(N + \theta/180)$, the deviation of the observed flash period from the true tumbling period is about +0·2 sec. in transits at 1° /sec. In the above equation, θ is the angle of movement of the line of sight during an observation.

The rotation period P has increased at a constant rate of 0·020 sec./day, from 10·5 sec. on July 18, 1960, to 14·0 sec. on January 8, 1961. During this interval, the orbital period has decreased only from 94·40 to 94·32 min.

It is of particular interest to compare the rate of decrease of angular momentum of spin for 1960 ζ1, with that for 1958 δ1 (*Sputnik* 3 rocket). Relevant details are set out in Table 2. The critical comparisons are between the respective values of the retarding couple $\mathrm{d}(I\omega)/\mathrm{d}t$ and the factors considered likely to determine these, principally the air density at perigee, and the length and profile area of each satellite.

Table 2. Factors Relating to the Rotation of Satellites 1960 ζ1 and 1958 δ1

Physical data assumed	1960 ζ1	1958 δ1
Length, L (cm.)	670	1,800
Diameter, D (cm.)	150	250
Mass, M (gm.)	$2·27 \times 10^6$	$4·5 \times 10^6$
Moment of inertia (gm.-cm.^{2}) $I = MD^2/16 + L^2/12$	$8·8 \times 10^{10}$	150×10^{10}
Interval considered	18/7/60 – 8/1/61	17/8/58 – 27/10/58
Angular velocity ω (rad./sec.) initial	0·60	0·349
final	0·45	0·254
Angular momentum $I\omega$ (gm.-cm.^{2}/sec.) initial	$5·28 \times 10^{10}$	$52·35 \times 10^{10}$
final	$3·96 \times 10^{10}$	$50·10 \times 10^{10}$
extrapolated to $\omega = 0·35$	$3·08 \times 10^{10}$	—
Fraction of time spent near perigee, f	1·0	0·1
$\mathrm{d}(I\omega)/\mathrm{d}t$ (dyne-cm.) initial	1,200	37,000 at $f = 0·1$
final	650	3,700 at $f = 1·0$
extrapolated to $\omega = 0·35$	400	—
Mean air density at perigee (gm.-cm.$^{-3}$)	$2·6 \times 10^{-13}$	$2·5 \times 10^{-13}$

The dimensions of 1958 δ1 are not accurately known. Notni and Oleak[1] derive from data by King-Hele[2] the relation $\rho DL/M = 2·86 \times 10^{-14}$ cm.$^{-1}$, where ρ is the air density at perigee (approximately 3×10^{-13} gm.cm.$^{-3}$). The rocket may have been heavier than the *Atlas* satellite (1958ζ), so M may have been as high as 5,000 kgm. From the observed brightness and large fluctuations of brightness, it is reasonable to expect $L \sim 20$ m., with $L \gg D$, while consideration of mechanical design suggests $L < 10D$. Assuming that the rocket body tapered to the base of the instrumented cone

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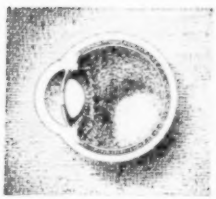

IN MAY—(1874)—James Clerk Maxwell philosophizes about colour vision. "I have here . . . a picture of the structure upon which the light falls at the back of the eye. There is a minute structure of bodies like rods and cones or pegs, and it is conceivable that the mode in which we become aware of the shapes of things is by a consciousness which differs according to the particular rods on the ends of which the light falls, just as the pattern formed by a Jacquard loom depends on the mode in which the perforated cards act on the system of movable rods in that machine. In the eye we have on the one hand light falling on this wonderful structure, and on the other hand we have the sensation of sight. We cannot compare these two things; they belong to opposite categories. The whole of Metaphysics lies like a great gulf between them."[1]

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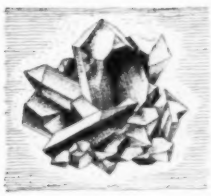

IN MAY—(1934)—Max Bergmann has yet to leave Dresden for the United States, but his papers are already appearing in American journals. This month, in *Science*, he discusses the use of carbobenzoxy amino acids in the synthesis of peptides. These "beautiful crystalline" substances can easily be transformed into their acid chlorides or azides, and the latter in turn condensed with other amino acids to yield carbobenzoxy peptides. The carbobenzoxy residue can then be readily eliminated without using a hydrolytic agent and thereby without risking a split in the peptide bond. Since carbobenzoxy amino acids are surprisingly stable to racemizing influences, it is now simple to prepare many optically active peptides previously considered practically inaccessible.[2]

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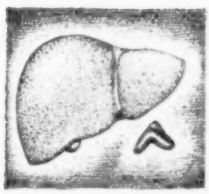

IN MAY—(1956)—Lowe and Rand discuss the ability of cortisone to produce certain changes in liver metabolism of RNA in rats.[3] They suggest that a variant RNA may be synthesized under the influence of cortisone or that normal RNA may be converted to this variant. This "new" RNA differs in solubility properties and rate of P^{32} incorporation. One of the more significant aspects of this variation is that it may be unable to act as a template for normal protein synthesis.

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1. Maxwell, J. C.: On colour vision, Nature, 4:13 (May), 1874. 2. Bergmann, M.: Synthesis and degradation of proteins in the laboratory and in metabolism, Science, 79:218 (May 18), 1934. 3. Lowe, C. U., and Rand, R. N.: Alterations in biochemical composition and ribonucleic acid metabolism induced in rat liver by cortisone, J. Biophys. and Biochem. Cytology, 2:331 (May 25), 1956.

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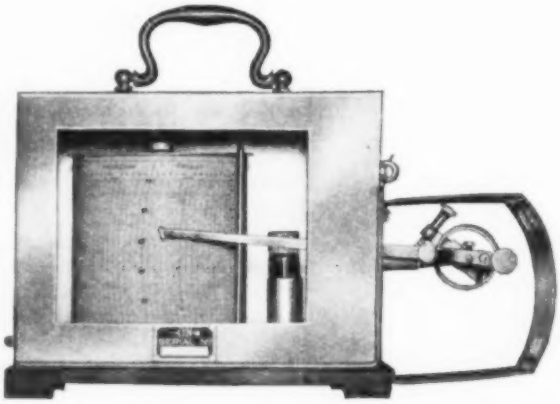

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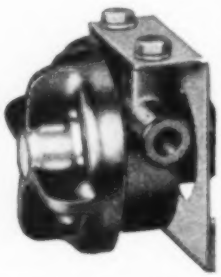

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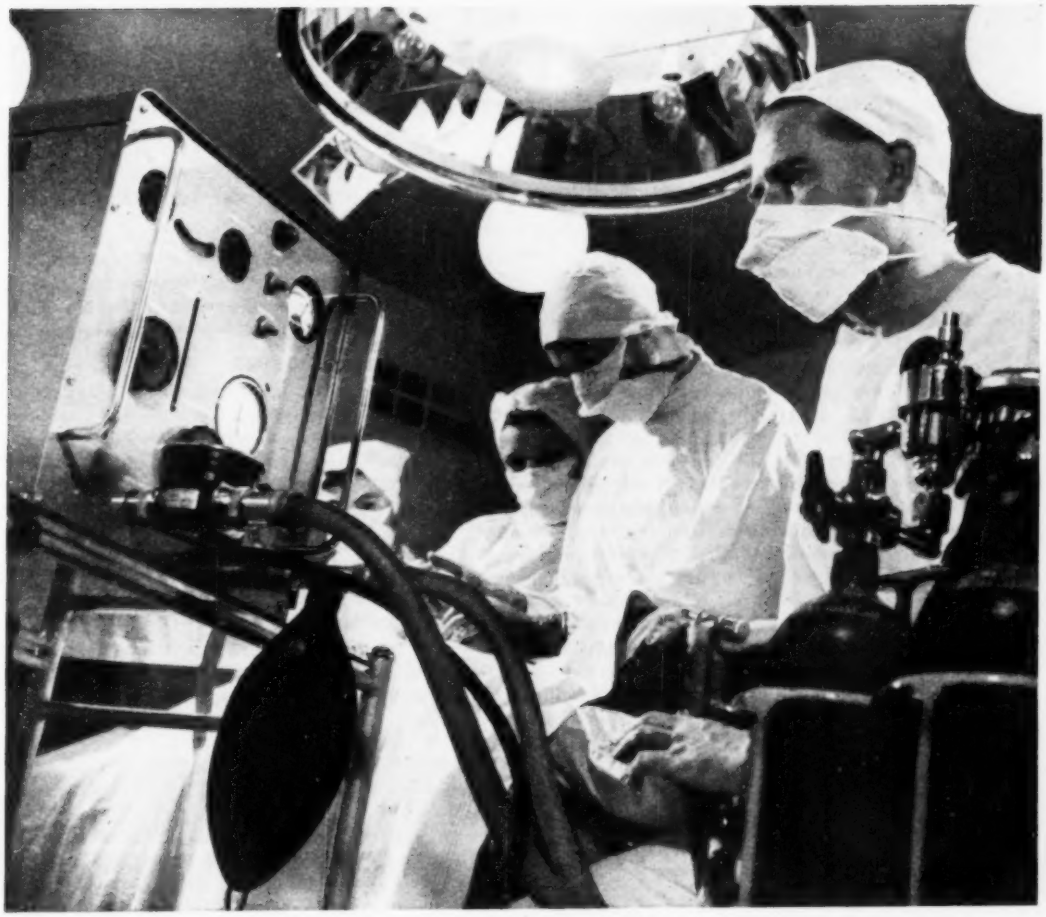

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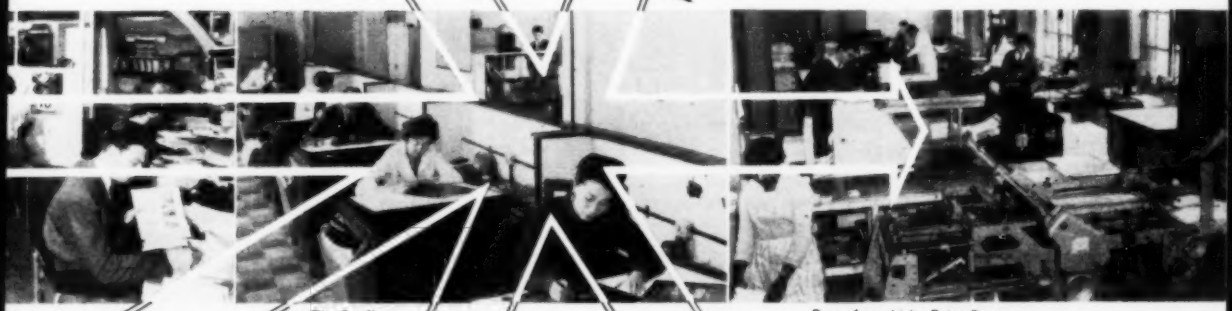

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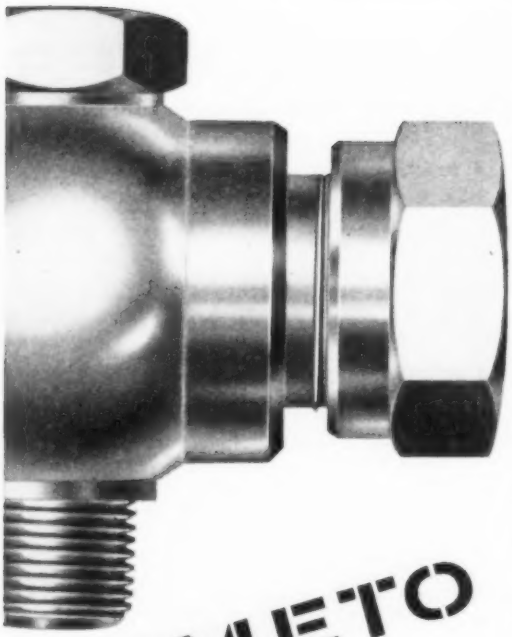

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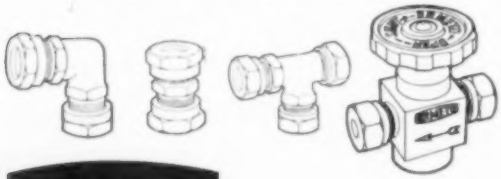

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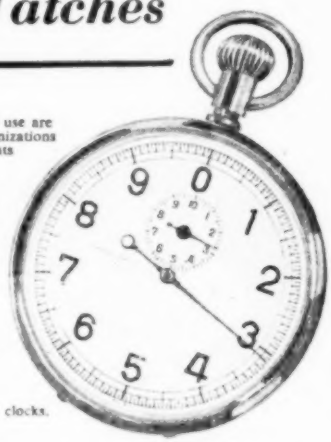

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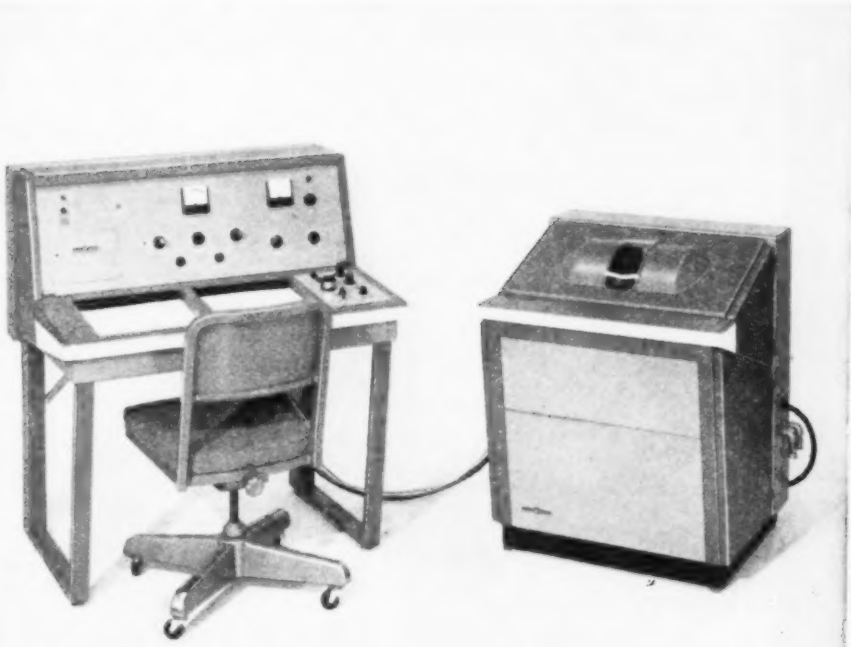

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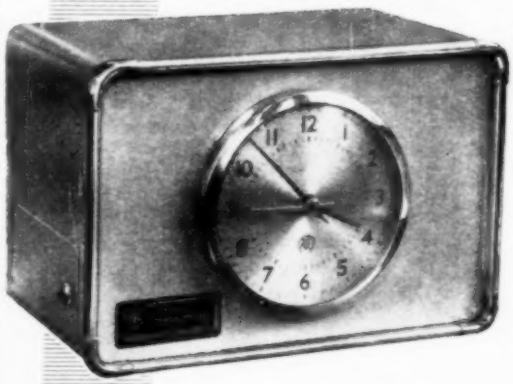

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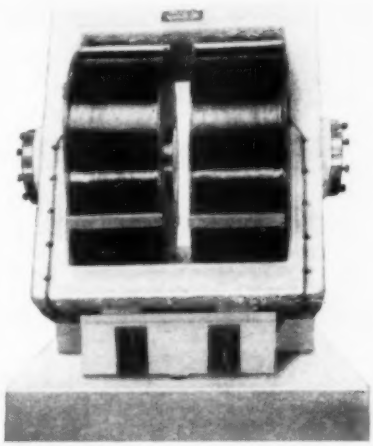

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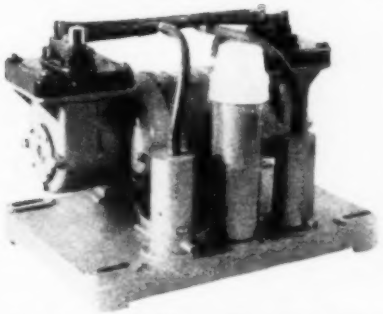

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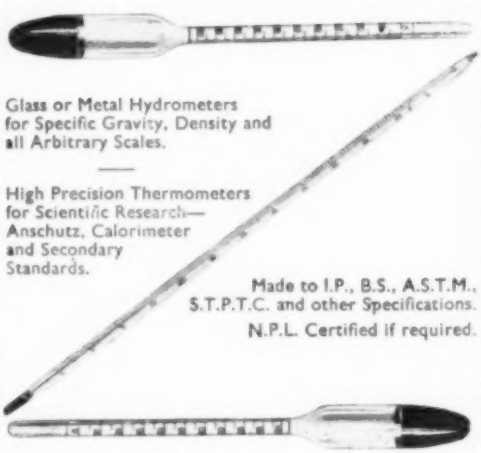

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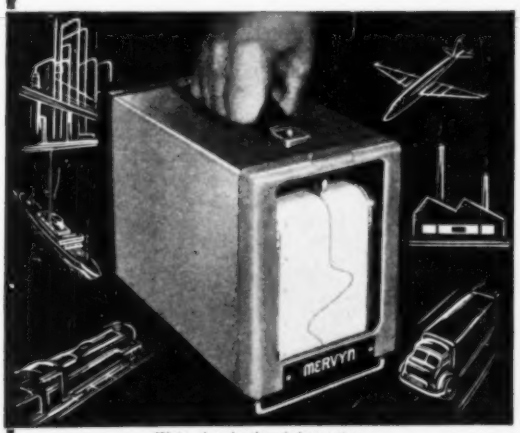

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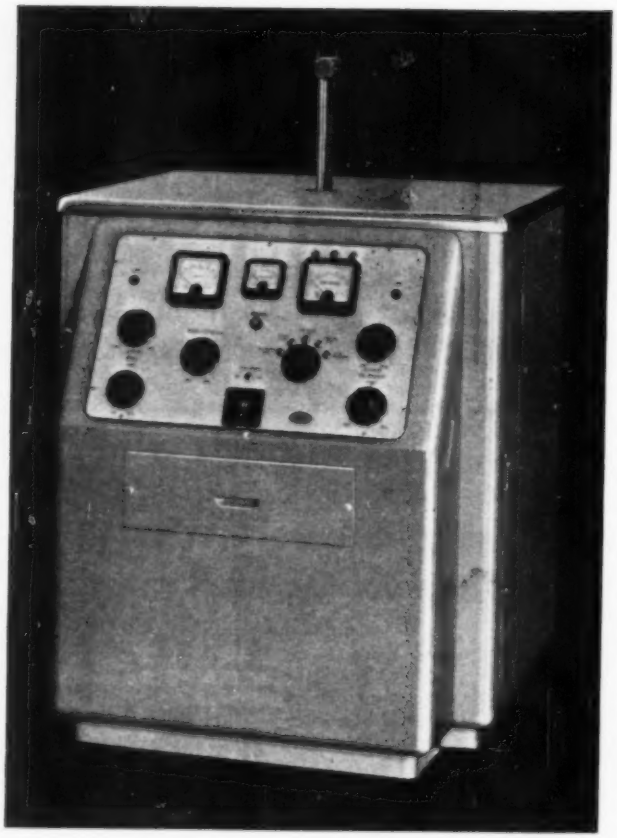

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(1958 δ2), (diameter 170 cm.), the data used in Table 2 are: $D = 250$ cm., $L = 1{,}800$ cm., $M = 4{\cdot}5 \times 10^5$ gm.

The retarding couple acting on 1958 δ1, concentrated in the transits through perigee ($f = 0{\cdot}1$), is of the order of 100 times greater than that acting on 1960 ζ1 at comparable rate of spin. This would explain satisfactorily the relative changes in terms of air friction, if the two satellites were known to be similar in weight and size. However, because 1958 δ1 was of such lower density and greater length, it is possible that the couple on it was much too small to permit this explanation, unless gross errors are present in the physical data assumed in Table 2.

If damping of satellite spin by the Earth's magnetic field is the controlling factor, even for the large empty rocket at a height of 220 km., the couple on 1958 δ1, averaged over the orbit ($f = 1{\cdot}0$), would be only about 10 times greater than that on 1960 ζ1. It is this possibility which I offer for critical analysis, in the light of the recent discussion[3] of the rotation of 1958 δ1.

The relative values of $d(I\omega)/dt$ would be even closer if either the weight or the moment of inertia of 1958 δ1 were appreciably less than assumed in Table 2.

C. R. Faulkner

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[1] Notni, P., and Oleak, H., *Pub. Babelsberg.*, **13**, 4 (1959).
[2] King-Hele, D. G., *Nature*, **183**, 527 (1959).
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PHYSICS

Thermal Shock Behaviour of Brittle Materials

We have been investigating the thermal shock behaviour of some glasses and other materials, using an argon plasma jet, as a preliminary part of an investigation into the thermal shock behaviour of brittle materials. The plasma jet was used in this investigation since it affords an easy and reliable method of producing very high heat transfer-rates of the order of 400–500 cal./cm.²sec. In the present experiments the samples, in the form of disks ½ in. thick and ⅞ in. diameter, could be shocked every 2 sec. for up to 1,000 times, the shock itself lasting about 0·16 sec. Under these conditions it was possible to obtain surface melting on such materials as soda glass, borosilicate glass and an electrical porcelain.

It was found, as a general rule, that where no surface cracking occurred during a single shock no cracking would be produced at all however many times

Fig. 1. Soda glass after 500 shocks at 75 cal. cm.²sec. Sheer crack during cooling

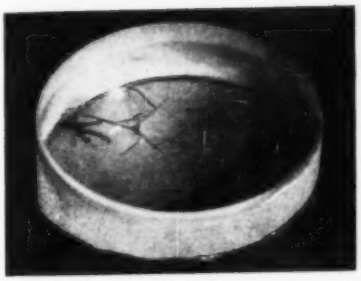

Fig. 2. Soda glass after 500 shocks at 75 cal. cm.²sec. Tensile cracking during cooling

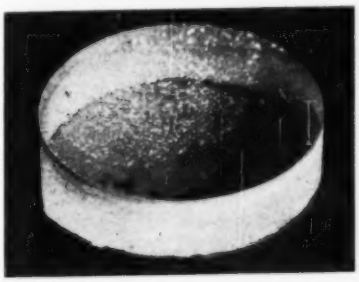

Fig. 3. Soda glass after 1 shock at 400 cal./cm.²sec.

the shock was repeated up to the maximum tried of 1,000 shocks. At low heat loadings, however, often nothing would be apparent on visual examination but cracks would appear later, sometimes weeks later, which were of a different form from those produced during a single shock. For example, with soda glass no cracks were observed by eye at heat loadings of 75 cal./cm.²sec. until several days after the experiment, when patterns of the type in Fig. 1 or Fig. 2 were produced. Fig. 1 indicates a shearing of the heated glass from the remainder and Fig. 2 shows cracking, in tension, of the surface during cooling. At higher heat loadings cracking occurred immediately (Fig. 3). Fig. 3 shows a series of shallow cracks generally radiating out from the central hot zone whereas Figs. 1 and 2 show only one or a few deep cracks. The surface completely disintegrated at the highest heat loading tried, 400 cal./cm.²sec., into a fused cracked mass, but again none of the cracks extended into the body of the disk.

The results obtained with a borosilicate glass were similar to those observed with soda glass, except that a greater heat loading was required to produce similar effects. No effects were observed at all with 75 cal./cm.²sec. but at 150 cal./cm.²sec. cracking of the types shown in Figs. 1 and 2 was found. At the higher heat loadings surface cracking and melting occurred. No surface cracks could be produced on silica with heat loadings in the range 75–400 cal./cm.²sec. but it was found that, on leaving for several months, the two samples which had received 100 shocks at 400 cal./cm.²sec. were cracked, one as in Fig. 1 and the other as in Fig. 2.

Electrical porcelain behaved similarly to the borosilicate glass. Typical samples are shown in Figs. 4 and 5. One unusual feature of these results was that the electrical porcelain often cracked into two halves, the crack following the path of the jet across the surface, whereas the only glass to crack bodily was the

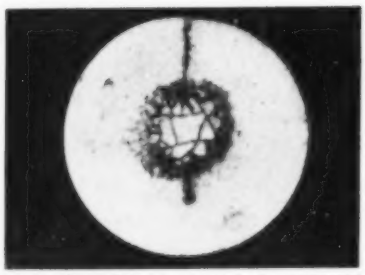

Fig. 4. Electrical porcelain after 1,000 shocks at 150 cal./cm.²sec. Note major cleavage crack in path of jet across surface

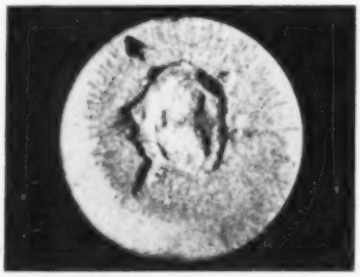

Fig. 5. Electrical porcelain after 10 shocks at 400 cal./cm.²sec.

soda glass and that did so normal to the path of the jet.

This work forms the initial stage of a fundamental study of the thermal shock behaviour of ceramic materials. I wish to thank Mr. Dugdale of the Metallurgy Division, United Kingdom Atomic Energy Authority, Harwell, for his advice and help during the earlier part of this investigation.

M. L. Levin

Hawker Siddeley Nuclear Power Co., Ltd.,
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The Parametric Line: a Photon and Gravitational Field Analogue

Let E and v be the energy and velocity of a pulse in a 'parametric line'[1], denoting the input and output ends by the subscripts 1 and 2 respectively. It has been shown[1] that the pulse energy amplification factor has the form:

$$E_2/E_1 = v_2/v_1 \qquad (1)$$

If this factor does not differ very much from unity, it can be written in the form:

$$E_2/E_1 = [\{(L/T)(v_2 - v_1)\}/\{\tfrac{1}{2}(v_1 + v_2)\}^2] + 1 \qquad (2)$$

where L is the length of the line, T is the time necessary for traversing the line and $\frac{1}{2}(v_1 + v_2)$ is the average speed of the pulse along it.

According to the General Theory of Relativity, an electromagnetic wave packet running over a length l in the direction of a gravitational field of intensity g (units of acceleration) gains frequency and hence energy[2]. The initial and final energies (ε_1 and ε_2) are related according to:

$$\varepsilon_2/\varepsilon_1 = 1 + \{gl/c^2\} \qquad (3)$$

where c is the velocity of light.

An analogy between equations (2) and (3) is established by substituting c for $\frac{1}{2}(v_1 + v_2)$, g for $(v_2 - v_1)/T$, l for L and ε for E. It will be noted that in each case the substitutions have the same dimensions.

Another analogy can be derived by considering the frequency spectrum of the pulse. Denoting the spread of the frequency by f and the duration of the pulse by τ, it follows from Fourier's theorem that:

$$\tau_1 f_1 = \tau_2 f_2 \simeq 1 \qquad (4)$$

It has been shown that in a parametric line (ref. 1):

$$\tau_1/\tau_2 = v_1/v_2 \qquad (5)$$

It follows from (4), (5) and (1) that:

$$E_1/f_1 = E_2/f_2$$

This equation resembles the energy frequency (ε, ν) relation

$$\varepsilon/\nu = h$$

where h is Planck's constant.

O. Nourse

High Green, Kiln Road,
Fareham, Hants.

[1] Physical Society Exhibition (demonstration 1960); further details to be published (*Phys. Soc. Handbook 1960*, p. 104).

[2] Wilson, H. A., *Modern Physics*, **6**, 332 (Blackie and Sons). Equation (3) may be derived by considering a small distance dr to which the field is considered uniform and by substituting ordinary units for the special units used. df/df is taken to be equal to $\tau_2 v_1 = \tau_1 v_2$. See also *Electronic Technology*, **39**, No. 7, 267.

Standard Unit of Pressure in Vacuum Physics

It is regrettable that spokesmen for the Bureau International des Poids et Mesures[1] and the Standards Division of the National Physical Laboratory[2] have failed to understand my recent communication[3].

Previous work on standardization has unfortunately resulted in the use of two units in the vacuum field, not related decimally to each other: millibar and torr, the latter being not equal to mm. of mercury[4]. My endeavour was to propose a practical solution to this problem much discussed by vacuum physicists and technologists in recent years. An attempt, therefore, was made to define a new unit which, being decimally related to both mm. mercury and c.g.s. (and m.k.s.) unit of pressure, could be considered as the standard unit of pressure in vacuum physics. The unit proposed, which was conveniently termed 'vac', should not be confused with millibar, as was done by the commentators mentioned above, the millibar invariably being nothing else than a multiple of the absolute unit of pressure, while the vac is defined in terms of the height of the mercury column under specified conditions. The new unit does not bring great implications in practical use. It represents an acceptable compromise to satisfy the international systems of units, and to avoid the replacement of mm. mercury by an arbitrary unit, like the torr.

I may mention that a detailed discussion of this matter has been reported elsewhere[5].

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School of Physics,
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Kensington, Sydney.

[1] Volet, Ch., *Nature*, **188**, 1017 (1960).
[2] Bigg, P. H., *Nature*, **188**, 1017 (1960).
[3] Florescu, N. A., *Nature*, **188**, 303 (1960).
[4] British Standards Inst., B.S. 2951 (1958).
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In order to obtain a unit of pressure in terms of the height of a column in a liquid manometer, a unit which is also related decimally to absolute units of pressure, Dr. Florescu proposes to elevate the pressure due to a 0·75-mm. column of liquid of density 13·5951 gm./cm.^{3}, g being 980·7455 cm./sec.^{2}, to the status of a new unit, and call it the 'vac'. But as Dr. Florescu admitted originally, this pressure is effectively 10^3 dynes/cm.^{2}, called internationally the millibar, and for the practical purposes of vacuum technology the pressure due to $\frac{3}{4}$ mm. of a standard mercury column (density 13·5951 gm./cm.^{3}, standard gravity 980·665 cm./sec.^{2}) is one millibar (more closely it is 0·999 92 mb.). Quite apart, therefore, from Dr. Volet's point, with which I entirely agree, I see no justification for introducing a new unit, the 'vac', the definition of which involves a new, arbitrary reference gravity, when the scale it would provide would in vacuum practice be indistinguishable from a scale of millibars.

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P. H. Bigg

Standards Division,
National Physical Laboratory,
Teddington, Middlesex.

METALLURGY

Anomalous Magnetostriction of the 'Grain-orientated' Silicon–Iron Sheet

This communication is concerned with the anomalous phenomenon occasionally found in examining the magnetostriction of the 'grain-orientated' silicon–iron sheets, and it was believed to be a prime cause which gives rise to a transformer noise. The method of measurement is the static one which has been adopted by us for a long time[1], and by this method the mean value of magnetostriction can be obtained. The experiments were carefully made with respect to a thin plate-like specimen.

The specimen contains 4·35 per cent silicon, and is used by a trade name of '*T*-90' in Japan. The specimen is a rectangular plate, 0·37 mm. thick, 6 mm. wide and 10 cm. long, and the direction of length corresponds to that of measurement and rolling. Fig. 1 shows a result for the specimen annealed at 600° C. for 1 hr. after cutting down the specimen from a large sheet.

As shown in Fig. 1, the magnetostriction does not appear up to 100 c.g.s. and then increases gradually, showing a minimum just before saturation with the increasing intensity of magnetization, and lastly, increases abruptly to a saturation value. It will be due to the 180° wall displacements that the magnetostriction does not appear in the first step. Adequate interpretation of this phenomenon may be very difficult, but we reasoned as follows.

In general, in iron-base alloys, including the 'grain-oriented' iron–silicon sheets, the magnetostriction is positive in an easy direction, and is negative in a hard direction. Therefore, the magnetostriction of polycrystal specimen is the sum of both values mentioned above, so that it is ordinarily encountered that the magnetostriction curve is either parabolic or exponential.

Now, in the range of continuous rotation of domain in the magnetization process, the mechanism

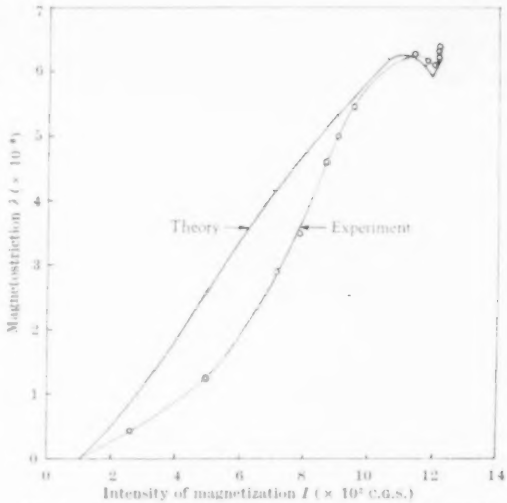

Fig. 1. Anomalous magnetostriction curves obtained experimentally and theoretically in the 'grain-orientated' silicon-iron sheet

of rotation may be greatly affected not only by the intrinsic crystal magnetic anisotropy but also by the additive restraint force or uniaxial anisotropy induced by rolling.

Some amount of the restraint force mentioned above may coincide with a special direction near an easy one. If so, in this direction, the domain rotations may be restrained, hence the magnetostriction does not appear below a critical magnetic field the energy of which surpasses the restraint force.

In such a way, the anomalous curve shown in Fig. 1 may be explained. Next, the simple theoretical expression may be given according to Heisenberg's theory of magnetostriction in the unsaturated magnetization region[2].

Using the above results and the magnetostriction constants obtained by Shturkin[3], and assuming that the fractions of orientation <100>, <110> and <111> are 0·3, 0·6 and 0·1 respectively, the theoretical magnetostriction can be calculated as shown in Fig. 1. A good agreement exists between the theoretical and the experimental results.

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[1] Honda, K., Masumoto, H., Shirakawa, Y., and Kobayashi, T., *Sci. Rep. Res. Inst. Iron, Steel and Other Metals* (Japan), **A, 1**, 341 (1949).
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[3] Shturkin, D. A., *Bull. Acad. Sci., U.R.S.S.*, **9**, 661 (1947).

Formation of Silicon Nitride Whiskers on a Ferro-Silicon Alloy at Room Temperature

After approximately ten years of operation, a calcium carbide furnace at Odda Smelteverk A/S, Norway, was temporarily stopped. At the bottom of the furnace a phase containing a ferro-silicon alloy was found. A sample taken from this bottom phase was kept in contact with air at room temperature. After a few weeks, formation of greyish-brown whiskers on the surface of the sample was observed.

These whiskers were removed, but after an additional few weeks needle-shaped crystals were again formed. This process has been repeated up to now, about one and a half years after the sample was taken out of the furnace. At present, however, the crystal growth seems to have almost ceased.

Chemical analysis of the sample on which the crystals grew gave the following result (weight per cent): iron, 82·4; silicon, 14·5; carbon, 2·85; calcium, 0; nickel, manganese, cobalt, vanadium, copper, titanium—minor impurities.

A metallographic investigation showed clearly that this substance contained only one ferro-silicon phase, the α-phase. The carbon appeared as a separate graphite phase.

The crystals forming the whiskers were investigated by X-ray analysis. From the powder diagrams, d-spacings were calculated. They were in almost perfect agreement with the X-ray lines given by Popper and Ruddlesden[1] for α- and β-Si_3N_4. Both allotropic forms were present in the crystals investigated.

The results of a quantitative chemical analysis of the crystals correspond to the composition $Si_{3\cdot04}N_4$.

Earlier investigations[2,3] describe cases where Si_3N_4 was formed during, for example, the nitriding process for case-hardening of steels containing small amounts of silicon. But in all cases the nitride was formed at temperatures not lower than 250° C.[4]

The results reported here, however, clearly demonstrate the formation of α- and β-Si_3N_4 on a lump of a ferro-silicon alloy even at room temperature. The kinetics of this process will be discussed elsewhere.

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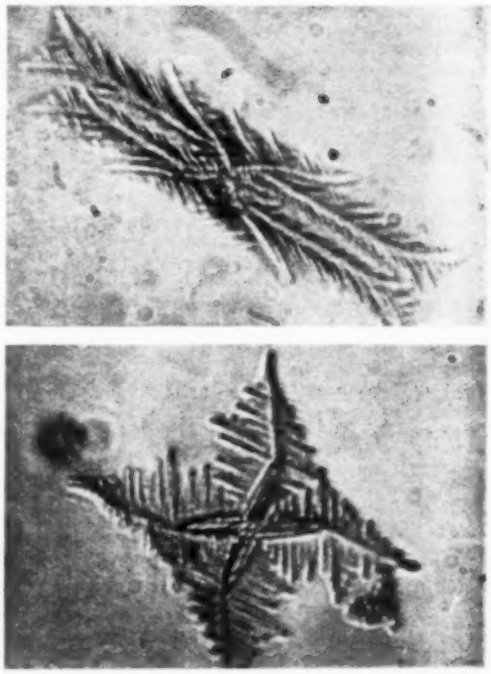
CRYSTALLOGRAPHY

Some Features of the Precipitation of Barium Chromate by an Extra-slow Technique

In the course of experiments concerning the preparation of very pure compounds, the precipitation of barium chromate was chosen as a model. S. Rykowski and I found[1] that a very slow precipitation with dilute solutions produces a precipitate which contains very minute crystals known as 'crystal skeletts'.

Continuing this work I have developed a technique of extremely slow precipitation, and I have observed some interesting features as regards the shapes of the crystals (see Fig. 1). A precipitate was obtained by addition of a dilute barium chloride solution to a large volume of potassium chromate solution and steady and vigorous mixing. After some hours minute crystals could be seen under the microscope (× 720–2,000). These crystals showed strikingly



Figs. 1 and 2

perfect symmetry, and some had regularly curved shapes. Besides the X-shaped crystals, very regular hexagonal plates and other more complicated forms appeared.

When ammonium chromate instead of potassium chromate solution was used, crystals of similar shapes were formed. Addition of potassium chloride (150 gm./l.) to the solution of potassium chromate produced exclusively crystals of the hexagonal type.

When a mixture of barium nitrate and silver nitrate (10: 1) was added to the solution of potassium chromate X-shaped crystals were formed. These crystals consisted of two parts of different shape and colour. It is assumed that the larger one is formed of barium chromate (pale yellow) the other one being silver chromate (dark brown) (see Fig. 2).

Barium sulphate and barium phosphate precipitates also showed interesting shapes of similar character.

Details of this work, which is being continued, will be published elsewhere. I wish to thank Mr. L. Trojanowski for his assistance.

Tadeusz Adamski

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Warsaw.

[1] Adamski, T., and Rykowski, S., *Polish Acad. Sci., Inst. Nuclear Res., Rep.*, 91/4 (Warsaw, 1959).

Retention of Carbon Dioxide Bubbles on Calcite Etch-Peaks

The etch-patterns on cleavage faces of calcite which have been reported[1–3] bear some interesting similarities and dissimilarities to etch-patterns obtained in this Laboratory. Watts etched calcite for 30 sec. in 1 per cent nitric acid and obtained five-

sided figures which he called pits. We immersed calcite in 0·001 *N* hydrochloric acid for one week and obtained essentially six-sided peaks (Fig. 1) with irregular valleys between them. The sixth side has a rougher surface than the other sides and it seldom extends to the apex of the peak. It may constitute an incompletely formed figure. Stanley used 10 per cent hydrochloric acid for 10–60 sec. and obtained figures which he describes as four-sided, although from his published photographs we detect a tendency of these figures toward the six-sided etch-patterns observed in our study. The Pandyas, using ammonium chloride, obtained parallelograms.

Another curious phenomenon was observed in this investigation. After the acid-carbonate reaction had proceeded long enough to etch the calcite surface, new carbon dioxide bubbles were nucleated on peaks of the etch-figures and remained there during their periods of growth (Fig. 2). A bubble would remain on a peak for a few seconds to many minutes, depending on the rapidity of the reaction. Escape of the bubble was followed quickly by the appearance of a new one on the same site. When such bubbles are viewed in silhouette, a gaseous stem is seen holding the bubble to the solid surface (Fig. 3). The end attached to the calcite remains stationary while the bubble is wafted to and fro by gentle currents in the acid solution. The remarkable 'contact angle' contrasts sharply with the attitude of carbon dioxide bubbles which form on uncleaned cleavage surfaces promptly after immersion in the dilute hydrochloric acid (Fig. 4).

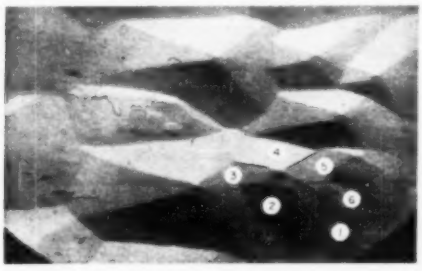

Fig. 1. Etch figures on calcite, magnification, × 87 ; illumination from top of page

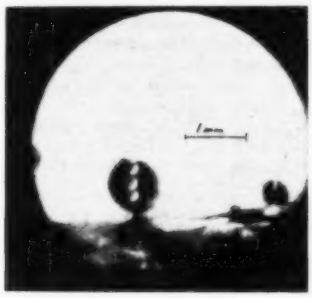

Fig. 2. Bubbles formed after etching, magnification, × 9

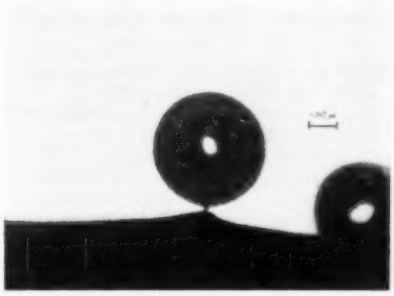

Fig. 3. Silhouette view of bubble on etch-peak, magnification, × 40

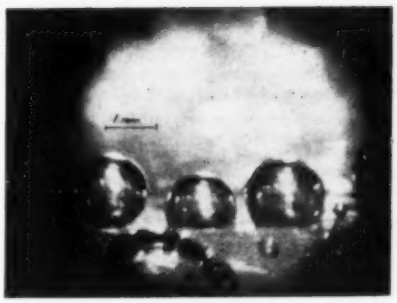

Fig. 4. Bubbles formed upon first contact of acid with calcite, magnification, × 7·5

The etch-peaks in Fig. 1 show a pinched appearance. It is suggested that this added erosion occurs during the up-sweep of comparatively strong acid that follows the escape of a bubble from the peak.

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GEOLOGY

Stilpnomelane in North Wales

THE occurrence of stilpnomelane in Great Britain was first recorded by Hallimond[1]. He described the mineral from the Pen-y-ralli mine in Merionethshire, where it occurs in a pisolitic ironstone bed at the contact with "a mass of igneous rock". The mineral occurs in association with chalybite in roughly parallel asbestiform veins up to one inch wide.

Present investigations in the region between Arthog and Dolgelley, Merionethshire, have shown that stilpnomelane is very common in certain basic marginal phases of the post Lower Llanvirn Cregennen granophyre sheet and in the associated 'mark-fieldites'. The mineral also occurs in some vitric (? welded) acid tuffs of the Lower Llanvirn Bryn Brith Series[2].

The analysed stilpnomelane-bearing granophyre from the upper contact zone consists essentially of quartz (generally granophyric), a little orthoclase, plagioclase (albite-oligoclase), and iron-rich chlorite mainly replacing actinolitic amphibole. Apatite is abundant together with ilmenite and sphene.

Stilpnomelane occurs as sharply terminated laths which are commonly arranged in either radiating sheafs or as 'bow-tie' aggregates. It appears to be

the last mineral formed in the rock and replaces chlorite and feldspar. It is also a constituent of small veins and fills occasional druses in the rock. The mineral is intensely pleochroic from pale yellow to a deep golden-brown or black and often shows varying degrees of alteration to a sub-isotropic reddish-brown vermiculite. The form and general characters of the mineral are identical with those of stilpnomelane from California[3].

A chemical analysis of the stilpnomelane-bearing granophyre gave the following: SiO_2 58·97, TiO_2 1·93, Al_2O_3 14·31, Fe_2O_3 2·10, FeO 9·21, MnO 0·21, MgO 2·37, CaO 2·76, Na_2O 4·60, K_2O 0·14, H_2O^+ 3·08, H_2O^- 0·14, P_2O_5 0·78, CO_2 0·00. Total 100·60 (analyst T. W. Bloxam). Detailed optical and chemical analyses of the stilpnomelane will be given in a later communication.

The mode of occurrence and relationships of the mineral are very similar to those of the stilpnomelane[4] from the Skaergaard intrusion, east Greenland. It is probable that the 'biotite' from the Cregennen granophyre[2] is in fact stilpnomelane—a conclusion which is supported by the low K_2O-content of the analysed rock.

Stilpnomelane in the acid tuffs has the same form as that in the basic granophyres, but shows less alteration to vermiculite. Frequently adjacent fibres are orientated at right angles to each other producing a type of 'mesh-structure' in thin sections[5]. The mineral replaces chlorite infillings of small vesicular aggregates and also fine-grained ashy material in the ground-mass.

We suggest tentatively that the stilpnomelane is a product of post-granophyre metasomatism accompanied by low-grade metamorphism equivalent to the chlorite sub-zone one[6]. Woodland[7] has already described the Cambrian (Harlech Series) north of the present area, and has noted the progressive metamorphism of these rocks.

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Lower Purbeck Beds of Swindon Facies in Dorset

In the course of a yet unpublished study of the pseudomorphs after gypsum prevalent in the 'Purbeck Caps' and 'Broken Beds' of Lower Purbeckian age in Dorset, a marl has been discovered with a fauna resembling that of the freshwater facies of the 'Swindon Series'. In the well-known Portisham quarry with the 'fossil elephant' (a silicified tree trunk[1]), the three-foot "impure marls with seams of chert" listed by Woodward[1] as occurring 9 ft. 6 in. above the Portland Stone have been found to contain the Swindon ostracod *Ulwellia papulata* Anderson, and well-preserved charophytes in abundance. Gastropods are also abundant and perhaps have Swindon affinities. None of these has been recorded before in British strata of indisputably Lower Purbeck age, and a full palaeontological investigation of the fauna is at present proceeding.

Lithologically the similarity in facies between the Dorset and Swindon beds is also well marked, and it is only with difficulty that the carbonaceous conglomeratic marl of Portisham can be distinguished from that of Swindon. At the former locality, however, there has occurred at places within this marl, the penecontemporaneous introduction of epigenetic lenticular gypsum. The geochemical conditions seem to have favoured silicification, which must here have been largely selective. The freshwater fossils are well preserved, and their presence in a rock full of pseudomorphs would seem at first sight to be anomalous. This appears to be due to the intercalation of the freshwater marl in an evaporitic succession marginal to the main gypsum deposits. These main gypsum deposits were rarely less than 6 ft. thick in the Broken Beds of the Lulworth region, where the 'Caps' were also very gypsiferous; at Portsdown and Henfield, anhydrite is dominant in the lower part of the Lower Purbeck[2].

At Swindon the freshwater nature of the greater part of the 'Swindon Series' has long been clear and they can be correlated with the Purbeck Beds of the Aylesbury district; but their correlation with the Purbeck Beds of Dorset has not previously been possible. A very thorough and painstaking investigation of these beds by Sylvester-Bradley[3] led to the realization that the fauna and flora, although differing in detail, were of a facies which at that time was known from Dorset only in the Middle Purbeck Beds. Twenty years ago Arkell and Sylvester-Bradley[4] discussed the age of the 'Swindon Series'. Arkell was convinced the evidence pointed to a Middle Purbeck age, but the view that the new discoveries strikingly support was that put forward by Sylvester-Bradley, who considered that the absence of *Cypridea granulosa* (Sow.) and *Cypridea fasciculata* (Forbes) suggested Lower Purbeck age.

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CHEMISTRY

Activity-based Diffusion Coefficients for Liquid Solutions

Whether an equilibrium concept is applied to a consideration for diffusion in liquids or whether the methods of irreversible thermodynamics[1,2] are used, it is clearly established that the driving force for molecular diffusion in liquids, such as occurs in the well-known diaphragm cell, is the gradient of the chemical potential. However, it has been the common practice to report diffusion coefficients calculated on the basis of concentration gradients as the driving force rather than the gradients of the chemical potential.

For the case of a binary (components A and B) non-ideal liquid system, the usual barycentric diffu-

sion coefficient, D (that is, taken with respect to the mass average velocity) is defined as follows[2,3]:

$$D = \mathfrak{D} \cdot \frac{\partial \ln a}{\partial \ln x} \qquad (1)$$

where $\mathfrak{D}$ is the binary activity-based diffusion coefficient, a is the activity of either component, and x is the corresponding mole fraction. The coefficient, $\partial \ln a/\partial \ln x$, is a measure of the deviation from ideal solution behaviour with a value of unity for ideal solutions. With $\partial \ln a/\partial \ln x$ accounting for such deviation, it would appear that $\mathfrak{D}(x)$ should not be affected by non-ideality since, being essentially a proportionality constant, it may be expected to be independent of the driving force associated with it. On this basis, it appears reasonable that the form of the function $\mathfrak{D}(x)$ should be the same for all binary systems, that is, the same as observed for ideal solutions. Data on some very nearly ideal solutions[4] do indicate that the form of the function $\mathfrak{D}(x)$ is a straight line or very nearly so.

Recent work by us[5] has provided extensive data on the ethanol–water system at 25° C. in agreement with earlier results[6]. The true or differential diffusion coefficients reported in both cases are D-values based on concentrations, and thus include corrections for non-ideality. Following equation (1) these results have been combined with the coefficients $\partial \ln a/\partial \ln x$ as computed by Guggenheim[7], using the vapour-pressure data of Dobson[8], on the assumption that

$$\frac{\partial \ln a}{\partial \ln x} = \frac{\partial \ln p}{\partial \ln x} \qquad (2)$$

where p is the partial pressure of the component with mole fraction x. Fig. 1 presents the results. The peculiar shape of this curve suggests the possibility of errors resulting from the difficulty of finding accurate shapes of vapour-pressure curves based on ten experimental points distributed over the total concentration range. This has been checked by integrating equation (1), using equation (2), starting from the pure component, and assuming that $\mathfrak{D}(x)$ is linear. This latter assumption, applied to the ethanol–water system, means that $\mathfrak{D} = 1{\cdot}22$ is constant. Using tabular integration, the partial pressures of ethanol and of water were determined at a series of compositions. The calculated pressures are shown on Fig. 2 by the continuous curves, together with the experimental points obtained by Dobson. The Duhem–Margules equation was used. Agreement with the experimental values being quite good, the use of a straight line for $\mathfrak{D}(x)$ does seem valid for this case.

Johnson and Babb[9], however, by applying similar corrections to their diffusivity data on the systems methanol–benzene and ethanol–benzene, obtained

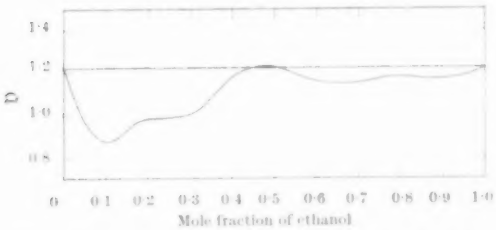

Fig. 1. Activity-based diffusivities in the ethanol–water system at 25° C., based on $\partial \ln p/\partial \ln x$ data as given by Guggenheim, and on measured values of D presented in ref. 5

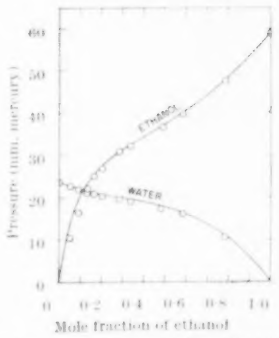

Fig. 2. Equilibrium vapour pressures (fugacities) in the ethanol–water system at 25° C. Continuous curves calculated by the equations,

$$D = \mathfrak{D}\,\frac{\partial \ln f_{\text{ethanol}}}{\partial \ln x_{\text{ethanol}}} = \mathfrak{D}\,\frac{\partial \ln f_{\text{water}}}{\partial \ln x_{\text{water}}}$$

using measured values of D, and $\mathfrak{D} = 1{\cdot}22$ cm.^{2}/sec., and assuming that the pure vapours behave as ideal gases. The circles denote experimental partial pressure values by Dobson (ref. 8)

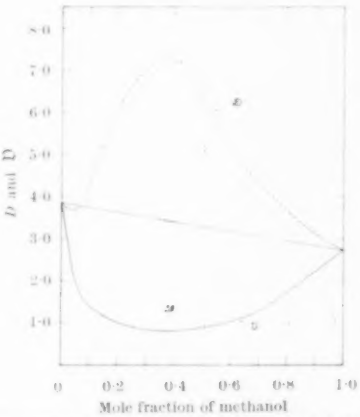

Fig. 3. Measured diffusivities D, and activity-based diffusivities, $\mathfrak{D}$ in the methanol–benzene system at 25° C., after Babb and Johnson (ref. 9)

curves for $\mathfrak{D}(x)$ that vary by more than 100 per cent and in no way approximate linearity. For the case of the methanol–benzene system they used the data by Scatchard *et al.*[10] at 35° C., which they corrected to 25° C. by an unspecified method.

This result, if correct, would certainly negate any speculation concerning the linearity of the function $\mathfrak{D}(x)$. There is little doubt that the vapour–liquid equilibrium data, as well as the measured diffusion coefficients, are essentially correct. There is a possibility of error in correcting the activity data to 25° C. To check this, the same integration procedure as used for the ethanol–water system was applied, using equation (1) for the measured diffusivities and the $\mathfrak{D}(x)$ curve by Johnson and Babb (Fig. 6, *loc. cit.*, and reproduced in Fig. 3). The curves then obtained are plotted in Fig. 4 as broken lines. It is noted that these curves do not pass through one point at 25° C. reported by Scatchard *et al.* The conclusion can be reached, however, that had Johnson and Babb used measured vapour-pressure curves at 25° C. to calculate $\mathfrak{D}(x)$, they would have obtained an even higher peak for this latter curve. In our opinion, the

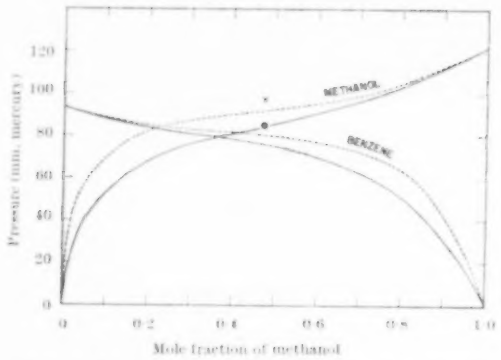

Fig. 4. Full lines are the fugacities in the methanol–benzene system at 25° C., as computed by the equations:

$$D = \mathfrak{D}\frac{\partial \ln f_{methanol}}{\partial \ln x_{methanol}} = \frac{\partial \ln f_{benzene}}{\partial \ln x_{benzene}}$$

using diffusivities given by Babb and Johnson (ref. 9) and a straight-line relationship for $\mathfrak{D}$. Broken lines show apparent values obtained by using the dashed curve on Fig. 3. × and ○ are measured partial pressures of methanol and benzene, respectively, after Scatchard *et al.* (ref. 10)

reason for the anomalous behaviour of the functions $\mathfrak{D}(x)$ as computed by Johnson and Babb, is the fact that benzene vapours do not form ideal mixtures with ethanol or methanol vapours. In the case of methanol at least, this has been experimentally verified by the observation of large heats of mixing in the system methanol vapour benzene vapour[11]. Under such conditions equation (2) should be replaced with the more general equation :

$$\frac{\partial \ln a}{\partial \ln x} = \frac{\partial \ln f}{\partial \ln x} \qquad (3)$$

where f is the fugacity of the component with mole fraction x. In such a case experimental vapour-pressure data obviously cannot be used for the purpose of making activity corrections. The calculated curve $\mathfrak{D}(x)$ of Johnson and Babb, based on an erroneous assumption, cannot be considered as an argument against the suggested linearity of the function $\mathfrak{D}(x)$. It is of interest to calculate the fugacities of the two components over methanol–benzene mixtures at 25° C. using the experimental diffusivities of Johnson and Babb and a straight-line relationship for $\mathfrak{D}(x)$ between the two end-points of the diffusivity-mole fraction curve. The relationship :

$$D = \mathfrak{D} \cdot \frac{\partial \ln f}{\partial \ln x} \qquad (4)$$

was used together with the vapour-pressures of the pure components. The curves obtained are plotted also on Fig. 4 as continuous lines. As might be expected, the relative deviation between the two curves increases monotonically from the pure component end and, eventually, stays constant at a maximum 'saturation' value.

It may thus be proposed tentatively that the measured diffusion coefficients, in conjunction with a straight-line relationship for the activity-based diffusion coefficient be used to calculate the coefficient $\partial \ln a/\partial \ln x$, and hence the activities in the liquid solution, and the fugacities in the equilibrium vapour, for binary solutions of non-electrolytes. This procedure would be simpler than existing methods, and would also eliminate the necessity for differentiation, which should result in a considerable improvement in accuracy. It is hoped that by making isothermal diffusivity and vapour–liquid equilibrium determinations on a number of non-ideal systems, along with investigations of the vapour-phase for possible deviations from ideal solution behaviour, it will be possible to subject the above suggestion to more extensive testing.

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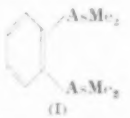
Complex Hydrides of Platinum

Following a recent investigation of the structure of some rhodium(III) and iridium(III) tertiary arsine complexes[1], which were shown to contain a metal-hydrogen bond, we have examined certain tertiary phosphine compounds of platinum and suggest that these also are complex metal hydrides.

These related compounds, which have the formulæ $[(PPh_3)_4PtH_2]^0$ and $[(PPh_3)_3Pt(H_2)]^0$, where PPh_3 is triphenylphosphine, were first prepared by Malatesta and Cariello[2a]. In the absence of evidence for the presence of metal-hydrogen bonds, they were originally formulated as tertiary phosphine complexes of zero-valent platinum. We have now shown that a third derivative $[(Ph_3P)_2PtH_2]^0$ (see ref. 2*b*) can be isolated from a benzene solution of either of the above hydrides, the other product of dissociation being triphenylphosphine. The compound $[(diarsine)_2PtCl_2]^0$, where diarsine has the formula I



(I)

has been prepared by treating $[(Ph_3P)_4PtH_2]^0$ with two moles of the diarsine in methylene chloride solution, the intermediate diarsine hydride reacting rapidly with the solvent. The properties of the various complex hydrides are given in Table 1.

The *tetrakis*-triphenylphosphine complex was prepared[2] by adding an aqueous solution of potassium tetra-chloroplatinate(II) to a solution of triphenyl-

Table 1. Typical Analytical Data

Compound	Colour	Melting point (° C.)	Calculated	Molecular weights In benzene	In nitrobenzene	In methylene chloride
$(PPh_3)_3PtH_2$	Ivory-yellow	116–118	1,242	400	915	—
$(PPh_3)_4PtH_2$	Yellow	125–130	982	420	800	—
$(PPh_3)_2PtH_2$*	Yellow-white	175–178	724	—	—	644

* Found: C, 60·8; H, 5·02 per cent; calculated for $C_{36}H_{32}P_2Pt$: C, 59·6; H, 4·4 per cent. Infra-red bands at 1,670 and 815 cm.$^{-1}$.

phosphine in alcohol containing potassium hydroxide. The reaction appears to be:

$$[PtCl_4]^{2-} + 2OH^- + 2C_2H_5OH + 4PPh_3 \rightarrow [(PPh_3)_4PtH_2]^0 + 2CH_3CHO + 4Cl^- + 2H_2O$$

The *tris*-triphenylphosphine complex was prepared[1] conveniently by adding hydrazine to a suspension of $[(Ph_3P)_2PtI_2]^0$ in ethanol.

The molecular weight in benzene found for the *tetrakis*- and *tris*-triphenylphosphine complexes may be interpreted in terms of a step-wise dissociation, namely:

$$[(PPh_3)_4PtH_2] \rightleftharpoons [(PPh_3)_3PtH_2] + PPh_3$$
$$[(PPh_3)_3PtH_2] \rightleftharpoons [(PPh_3)_2PtH_2] + PPh_3$$

The molecular weight in benzene indicates complete dissociation of both the *tetrakis*- and *tris*-compounds. This marked dissociation may, as suggested by Malatesta and Cariello[2], be due to some interaction of the complex with the solvent. This seems to be supported by the fact that the molecular weights in benzene are dependent on time; also, the benzene solutions show new infra-red bands which are not attributable to the solvent, the ligand or the complexes already mentioned. The dissociation is clearly much less in nitrobenzene (see Table 1).

The infra-red spectra have been studied, and some platinum–hydrogen active frequencies are shown in Table 1. As in other metal hydrides[3], the bands are characteristic of the metal-hydrogen stretching in regard both to frequency and shape. It is of interest to note that no Pt—H stretching frequencies in the usual region have been observed for the compounds $[(PPh_3)_4PtH_2]^0$ or $[(PPh_3)_3PtH_2]^0$. This is confirmed by deuteration studies. In contrast, however, the deuterium analogue of $[(PPh_3)_2PtH_2]^0$, prepared from a deuterated sample of $[(PPh_3)_3PtH_2]^0$, does show the presence of a Pt—D stretching frequency.

The number of hydride ligands in the *tetrakis*- and *tris*-compounds was determined by studying spectrophotometrically the amount of bromine consumed by these compounds. Known amounts of the solid complex were added to a standard solution of bromine in methylene chloride, and the disappearance of bromine studied by observing the absorption at 500 mμ. In both cases a sharp end-point occurred after 2 moles of bromine had been added; extraction of the resulting solution with water and titration of this with alkali revealed that 2 equivalents of hydrogen bromide had been produced:

$$[(PPh_3)_3 \text{ or } {}_4PtH_2]^0 + 2Br_2 \rightarrow [(PPh_3)_2PtBr_2]^0 + 2HBr + 1 \text{ or } 2\ PPh_3$$

The infra-red spectrum of the $[(PPh_3)_2PtBr_2]^0$ produced shows no Pt—H bands.

Further evidence for a Pt—H bond in the *tetrakis*- and *tris*-complexes is also provided by the vigorous reaction which they undergo with carbon tetrachloride to yield chloroform—a reaction which is characteristic of metal hydrides[3]. The composition of the products was established by vapour phase chromatography.

The fact that these triphenylphosphine adducts are considered to be hydrides of bivalent platinum raises the interesting question of whether any truly zerovalent complexes of platinum have yet been prepared; especially as the above hydrides have often been used as the intermediates in the preparation of certain Pt^0 compounds.

Thus, in the above compounds, in which the platinum atom is regarded as bivalent with a d^8 non-bonding configuration, we have examples of the metal atom with co-ordination numbers of 4 (cf. $[PtCl_4]^{2-}$), 5 (cf. $[Pt(diarsine)_2Br]ClO_4$[5]) and 6 (cf. $[Pt(triarsine)_2][ClO_4]_2$[6], $[Au(diarsine)_2I_2]ClO_4$[7]).

We thank Dr. G. K. N. Reddy and Mr. K. Khaleeluddin for their assistance. One of us (J. A. C.) gratefully acknowledges the award of a Fulbright fellowship, during the tenure of which this work was carried out.

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A Sealed-edge Theory of Graphite 'Compounds'

In the stepwise formation and decomposition of certain graphite compounds, notably the bisulphate and the potassium compounds, surprise has often been expressed that one layer of carbon atoms can influence the behaviour of other layers that are several times the spacing of 3·35 Å. away.

The following tentative theory explains this by centering attention on the carbon atoms at the edges of the layers. It is generally agreed that these edge atoms are bonded to oxygen, hydrogen, hydroxyl or hydrocarbon residues and perhaps to similar atoms in adjacent layers. Now if such bonds between edge atoms do exist, either directly or through oxygen or hydrocarbon residues, then it is reasonable that not all of them from a given layer are directed to the same adjacent layer. Openings will therefore be available through which adducts can diffuse into the

central volume, the sheathing layers of which are thereby forced out to two or three times their normal separation. If, however, the edge atom separations throughout the crystal are unaffected, the displaced layers will decrease the spacing to the next layers and may transmit the effect to several successive layers. This contraction is probably most significant near the edges, and indeed need be significant only there to influence diffusion to the central region. If great enough, it will prevent the occupation of one or more layers adjacent to a filled one. The theory therefore explains the non-filling of blocks of spaces in the formation of the compound and the emptying of blocks of spaces during decomposition. Various isotherms, kinetic studies, and other data will shortly be published to support the theory.

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Field-Emission Microscopic Investigation of Catalysed Synthesis of Ammonia on Tungsten

FIELD-EMISSION microscopy was applied to the investigation of the mechanism of the catalysed synthesis of ammonia on tungsten. It was concluded from the result that (1) the dissociative adsorption of nitrogen is considerably accelerated by the presence of hydrogen, and that (2) the rate-determining step of the synthesis is either the formation of adsorbed imino-group NH(a) from adsorbed nitrogen atom N(a) and hydrogen atom H(a), or that of adsorbed amino-group NH_2(a) from NH(a) and H(a) but not the dissociative adsorption of nitrogen, as is generally accepted.

Nitrogen, hydrogen, a 1 : 5 mixture of nitrogen and hydrogen, and ammonia were allowed, in turn, to be adsorbed on the clean tungsten tip of a field-emission microscope, while pressure was increased gradually from 10^{-9} to 10^{-7} mm. mercury and then decreased by evacuation. After evacuation was begun, the tip was subjected to intermittent heat treatments at temperatures raised successively from 500 to 3,000° K. Field-emission patterns and the associated changes of average work function were observed at liquid-nitrogen temperature for each series of gases along with the initial increase followed by decrease of pressure as well as after every heat treatment.

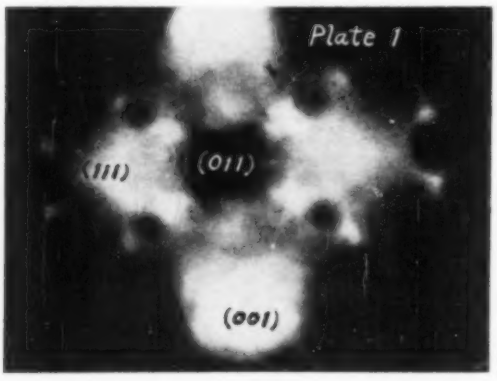

Fig. 1. The N(a) pattern has characteristics of the bright surroundings of the (001)-region and of the bright (111)-region. The increase of average work function $e\Delta\varphi$ is about 0·35 eV. from the initial value of the clean tungsten surface

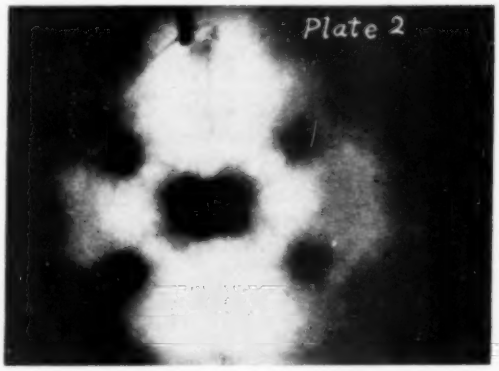

Fig. 2. The characteristics of the H(a) pattern are shown by the bright region spread toward the centre of the dark (011)-region along the (111)–(011) zone and the relatively darker (111)-region along the zone. $e\Delta\varphi$ is about 0·05 eV.

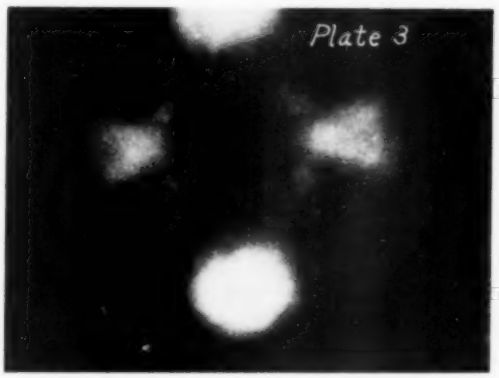

Fig. 3. The pattern of the nitrogen–hydrogen mixture is the superposition of the N(a) and H(a) patterns. $e\Delta\varphi$ is about 0·5 eV.

Figs. 1 and 2 show the patterns observed steadily at the later stage of the nitrogen and the hydrogen series. These patterns, along with associated changes of the average work function, were judged to be characteristic of N(a) and H(a). Fig. 3 is a pattern observed for a nitrogen–hydrogen mixture, which is identified as a superposition of the N(a) and H(a) patterns. Conclusion (1) was arrived at from the early appearance of a N(a) pattern in the latter series as compared with that in the nitrogen series. Fig. 4 for ammonia gives a pattern which is distinguishable from the patterns characteristic of N(a) and of H(a). The latter characteristic was attributed to NH(a) and/or NH_2(a) in agreement with an associated decrease of average work function.

The characteristic pattern of N(a) was observed with ammonia, just after the heat treatments at elevated temperatures. Similarly, patterns characteristic of NH(a) and/or NH_2(a) were observed with a nitrogen–hydrogen mixture after the heat treatments at elevated temperatures, but they were unstable.

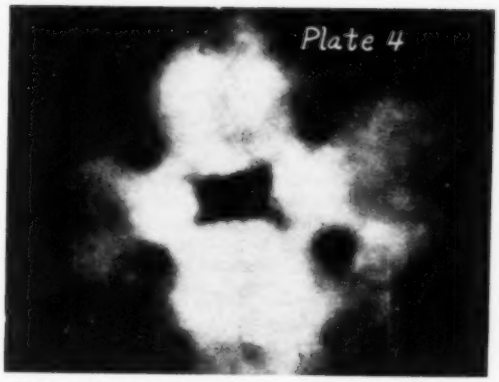

Fig. 4. The pattern of ammonia has the characteristically bright and dark regions along the (001)-(011) zone. $e\text{-}\frac{1}{2}\varphi$ is about −0·1 eV.

These results indicate that N(a) on one hand and NH(a) and/or NH_2(a) on the other hand are walled off from each other by a slow step, which is just surmounted in either direction by the later heat treatments; hence the conclusion (2) is arrived at, suggesting that catalysed ammonia synthesis proceeds through the sequence of steps: $N_2 \rightarrow 2N(a)$, $H_2 \rightarrow 2H(a)$, $N(a) + H(a) \rightarrow NH(a)$, $NH(a) + H(a) \rightarrow NH_2(a)$ and $NH_2(a) + H(a) \rightarrow NH_3$.

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Detection of Trace Quantities of Acenaphthene by Gas Chromatography

In the course of investigations into the *c*-mitotic effect we wished to determine the acenaphthene uptake in the root tips of onions grown in a saturated water solution of acenaphthene. As the quantities expected were of the order of μ, the very sensitive flame ionization detector described by McWilliam and Dewar[1] was used. A 6-in. long ¼-in. bore column packed with 60–80 mesh brick dust carrying 15 per cent w/w silicone oil was used for the analysis, and pure hydrogen was used as the carrier gas.

Because of the small amounts of material being handled it was necessary to introduce the samples on to the column in a solvent. For this purpose it was found that redistilled commercial 'Decalin' (b.p. 184–187° C.) was suitable. At the temperature of the column (183° C.) the main peaks of the 'Decalin' had been eluted before the appearance of the acenaphthene peak, and, although the sample used 'tailed' badly, the tailing was not sufficiently serious to interfere badly with the detection of acenaphthene.

More volatile solvents or solvent mixtures had, of course, very short retention times, and tended to give a sooty flame which interfered with the operation of the detector.

Tests with prepared solutions showed that we could detect quantities as small as 0·2 μgm. acenaphthene.

Onion roots were treated with ether and the extract, after evaporation to dryness at room temperature, was redissolved in 0·25 ml. decalin. 20-μl. samples of decalin solution were injected on to the head of the column. The detector sensitivity was turned down to minimum until the main decalin peaks had been eluted and was then increased until the 'noise-level' was about 2 per cent of full scale.

Chromatograms made with extract from onions grown in pure water showed no peaks in the region about the retention time of acenaphthene. The extract from onions grown in acenaphthene solution and showing *c*-mitotic activity gave peaks which on comparison with the test chromatograms correspond to about 5 μgm. acenaphthene (that is, about 60 μgm./gm. of root tip).

An attempt was made to determine the solubility of acenaphthene in water. 10 ml. of saturated solution was evaporated to dryness and any residue dissolved in 0·25 ml. decalin. No trace of acenaphthene was found in this solution. The solubility of acenaphthene is therefore less than 250 μgm./l. These results suggest a considerable uptake of acenaphthene in the root tips, the significance of which will be discussed in a later paper in conjunction with other experiments on the *c*-mitotic effect.

We wish to thank Mr. A. Adam for his invaluable assistance with the design and construction of the electronic equipment.

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Polypeptide Formation from Asparagine under Hypothetically Primitive Conditions

This is a report of the formation of polyaspartic acid from asparagine[1] in aqueous solution under conditions which satisfy suggested primitive terrestrial conditions[2] better than thermal polycondensation[3,4].

When an aqueous solution of L-asparagine (5–10 per cent) was refluxed for several days, a part of the asparagine hydrolysed to aspartic acid; the other somewhat larger part formed a non-crystalline product[5]. This non-crystalline product was a mixture of aspartyl oligo- and poly-peptides which were separated as either water-insoluble Cu(II) or Pb(II) salts. Lyophilization of the solution of the free peptides, obtained with hydrogen sulphide from the salt, gave a white material. The yield was 62 per cent. When the polymerization of asparagine was carried out at 70–75° instead of 100°, the yield was 18 per cent. Van Slyke amino-nitrogen determination and dinitrophenol end-group analysis indicated average molecular weights between 380 and 530, corresponding to 3·3 and 4·4 units per molecule. Paper chromatogram (butanol–water or phenol–water) demonstrated the presence of a series of aspartic acid peptides, polypeptides and some aspartic acid. β-Aspartylaspartic acid was identified as being one of the oligopeptides present by comparison of the R_F value with that of an authentic sample[6].

Polyaspartic acid of higher molecular weight was obtained by dialysis of the original solution or of the

crude polypeptide mixture. The average molecular weight of various preparations ranged from 1,700 to 3,000 (15–26 units) as determined by Van Slyke and dinitrophenol methods. Like α,β-polyaspartic acid[1], this polypeptide was highly soluble in water and gave a positive biuret reaction. The infra-red absorption spectrum was identical with that of polyaspartic acid[1c] (bands: NH stretching near 3μ; CO of carboxyl group 5·85μ; amide I 6·05μ; amide II 6·55μ) confirming the polypeptide structure. It is reasonable to assume that the polymerization of asparagine involves an intermolecular non-enzymatic transamidation reaction.

This work was supported by a research grant (*RG* 6579) from the National Institute of Health, Public Health Service.

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BIOCHEMISTRY

Enzymatic Formation of Histamine Ribotide from Histamine Dinucleotide

Alivisatos *et al.*[1,2] reported the formation of histamine dinucleotide, that is, the pyrophosphate of histamine 5′-ribotide and of 5′-adenylic acid, from diphosphopyridine nucleotide (DPN) and histamine, using a soluble, purified preparation of diphosphopyridine nucleotidase[3] (DPNase) from bovine spleen. It has been shown that nicotinamide[4,5] inhibits the release of histamine by antigen from the lung tissue of a sensitized guinea pig. Nicotinamide is a known inhibitor of DPNase and nicotinamide ribosidase[6]. These facts suggest the possibility that part of the histamine released during the antigen–antibody reaction is formed from histamine dinucleotide.

The present report describes some properties of histamine dinucleotide and of histamine ribotide. These compounds were recently isolated as pure preparations in the course of work which was concerned with the biological significance of histamine dinucleotide and related compounds, and with the formation of free histamine from such compounds. The formation of histamine ribotide had hitherto been reported only qualitatively by paper chromatographic and electrophoretic results[2].

$$\text{DPN} + \text{histamine} \xrightarrow[\text{bovine spleen or pig brain}]{\text{DPNase from}} \text{histamine dinucleotide} + \text{nicotinamide} + \text{H}^+ \quad (1)$$

The reaction (1) proceeded easily with DPN and histamine (2-^{14}C) as substrates, and with the use of insoluble, partially purified DPNase[7] from bovine spleen or pig brain. The reaction product, histamine dinucleotide, was found to be present in the fraction eluted from a column of 'Dowex-1' (*X*10, chloride form) by 0·002 *N* hydrochloric acid (*p*H 2·9). The dinucleotide, recrystallized from acetone–water mixture after lyophilization, did not lower the blood pressure of a cat and did not contract the ileum of a guinea pig *in vitro*. The dinucleotide was easily hydrolysed when heated with 2·5 *N* hydrochloric acid in a sealed tube at 150° C. for 5 hr. The free histamine was identified by its action on the cat's blood pressure and the guinea pig's ileum.

$$\text{Histamine dinucleotide} \xrightarrow[\text{diesterase}]{\text{phospho-}} \text{histamine ribotide} + \text{AMP} \quad (2)$$

100 mgm. of histamine (2-^{14}C) dinucleotide (purity, 88 per cent; specific activity, 1,419 e.p.m./μmole), obtained by the reaction (1), was incubated at 37° C. for 5 hr. in the presence of phosphodiesterase[8], purified from snake venom. Chromatography of the reaction mixture through a column of 'Dowex-1' (*X*10, chloride form) gave a radioactive fraction of histamine ribotide, having no absorption at 260 mμ, by elution with 0·001 *N* hydrochloric acid (*p*H 3·1) (Fig. 1). Fig. 1 also shows a substance having absorption at 260 mμ, obtained by elution with 0·004 *N* hydrochloric acid (*p*H 2·4). This substance was identified as 5′-adenylic acid (AMP) by paper chromatography.

The fraction containing histamine ribotide was first lyophilized and recrystallized from acetone–water mixture to 25 mgm. (yield, 58 per cent) of the crystals, m.p. 176–180° C. (decomp.), of this substance. The specific activity of this sample, calculated from the formula of the ribotide as $C_{10}H_{18}O_7N_3P \cdot HCl$ (359·5), gave 1,466 e.p.m./μmole, which agrees with that of the original dinucleotide. The ultra-violet spectrum of the dinucleotide exhibits absorption maxima at around 210 mμ and at 258 mμ, and that of ribotide at around 210 mμ. Both were positive to the ninhydrin and phosphate reactions. The R_F values on a paper chromatogram, using 0·1 *M* acetic acid/ethanol (1 : 1) mixture as a solvent, was 0·45 for the dinucleotide and 0·58 for the ribotide. The observed values for ribose per 1 μmole of the compound were 1·80 (calc., 2·00) for the dinucleotide and 0·96 (calc., 1·00) for the ribotide by periodate consumption, but were 0·86 for the dinucleotide and 0 for the ribotide by the orcinol reaction. The lower values of ribose by the latter method are considered to be due to the stability of the N—C

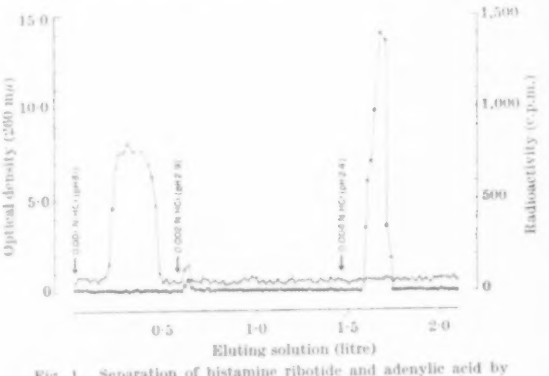

Fig. 1. Separation of histamine ribotide and adenylic acid by 'Dowex-1' (*X*10) in a chloride system. Fractions of 10 ml. were collected, and the radioactivity (○) and the optical density at 260 mμ (●) of each fraction were measured

bond between the imidazole and ribose in both substances[8]. However, this N—C bond is cleaved by decomposition with hydrochloric acid under a high pressure, liberating biologically active histamine in 40–83 per cent yield and inorganic phosphate in a yield close to 100 per cent of the theoretical value. The diazo reaction using sulphanilic acid on a paper chromatogram appears orange coloured in the dinucleotide and yellow in the ribotide. The absorption spectrum of the reaction solution, however, lacks the peak at 530 mμ characteristic of histamine in both substances, and a peak, assumed to be that of an azo compound, is observed at 380 mμ.

Histamine ribotide contracted the ileum of a guinea pig, but this action differed from that of histamine in that the contraction occurred gradually and was not inhibited by an antihistamine ('Neoantergan').

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Inhibition of Chymotrypsin with Diisopropyl Phosphorofluoridate

In a recent article Stein and Laidler[1] described the inhibition of chymotrypsin by di*iso*propyl phosphorofluoridate (DFP). They found that even when the inhibitor-enzyme ratio was as high as 4 : 1 no complete inhibition was observed. This was contrary to the results of Jansen *et al.*[2], who found that when the molar ratio of DFP to enzyme was more than unity, there was practically 100 per cent inhibition.

Stein and Laidler concluded from their results that under their conditions the interaction between DFP and chymotrypsin is reversible. Further evidence of the reversibility was derived from the results of experiments where the enzyme was added to a mixture of DFP and substrate (methyl hydrocinnamate). They found that the greater the substrate : inhibitor ratio the less was the falling-off of the substrate-splitting rate as the reaction proceeded.

The discrepancy between these results and those of Jansen *et al.* was attributed to a small amount of propanol in the reaction medium of the latter.

In a rather comprehensive study on the relationship between structure of organophosphorus compounds and their ability to inhibit esterases and related enzymes[10] I also studied the inhibition of chymotrypsin by DFP.

The inhibition reaction was carried out at 25·0° C. and at *p*H 7·7 either in 0·1 *M* phosphate buffer or in 0·0033 *M* sodium veronal buffer. At intervals,

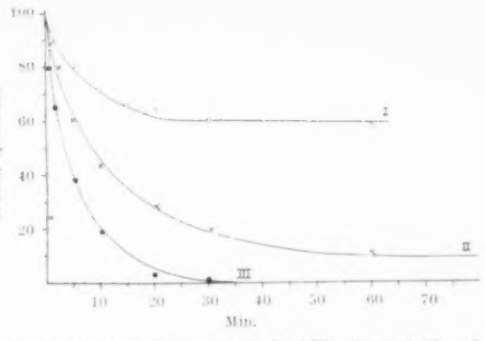

Fig. 1. Inhibition of chymotrypsin by DFP. Concentration of enzyme : $6{\cdot}6 \times 10^{-6}$ *M*. ○, Concentration of DFP, $2{\cdot}76 \times 10^{-6}$ *M* ; ×, $6{\cdot}45 \times 10^{-6}$ *M* ; ●, $1{\cdot}29 \times 10^{-5}$ *M*. All inhibition reactions carried out at *p*H 7·7 and 25° C.

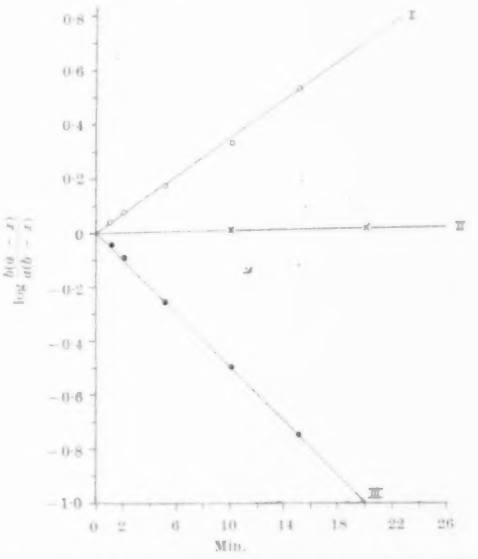

Fig. 2. The rate of inhibition of chymotrypsin by DFP. Concentration of DFP and enzyme the same as in Fig. 1

samples were withdrawn and the remaining enzyme activity was measured either by Anson's haemoglobin digestion method[3] or by measuring the rate of hydrolysis of L-tyrosine ethyl ester at a substrate concentration of 0·025 *M*[4]. In carrying out these activity measurements, the inhibitor-enzyme mixture was diluted about 10 times.

I was able to demonstrate that under my conditions the inhibition reaction was virtually stopped.

I found that the proteolytic activity is inhibited at the same rate as the esteratic activity, a result which is in agreement with the results of Jansen *et al.*[2] and Hartley and Kilby[5].

Figs. 1 and 2 give the results of three typical runs. From these kinetic data I calculated the bimolecular rate constant for the inhibition reaction. This has been done for the reaction of chymotrypsin with paraoxon by Hartley and Kilby[5]. In their case, however, pseudo first-order kinetics could be used, for a very large excess of paraoxon is needed in order to get proper enzyme inhibition within reasonable time. The

authors remarked, however, that DFP inhibits chymotrypsin in such low concentration that the enzyme and inhibitor must be present in about equimolecular amounts.

That this is the case appears from a comparison of the concentrations of DFP used in the experiments of Fig. 1 and the enzyme concentration used, the latter being $6{\cdot}6 \times 10^{-8}\,M$. In these circumstances the second-order kinetics calculation has to be used. The well-known formula for the rate constant is:

$$k = \frac{1}{t} \times \frac{1}{a-b} \ln \frac{b(a-x)}{a(b-x)} \qquad (1)$$

a and b being the initial concentrations of enzyme and inhibitor respectively and x the concentration reacting in time t. In Fig. 2 $\log \frac{b(a-x)}{a(b-x)}$ is shown in relation to t. Straight lines are obtained; the slopes of these lines give the bimolecular rate constant. It was found that under our conditions:

$$k = 1{\cdot}9 \times 10^{4}\ \text{l.mol.}^{-1}\text{min.}^{-1}$$

This value corresponds very well with a value published by Jandorf *et al.* ($2{\cdot}0 \times 10^{4}$) without experimental conditions given, however[6].

The influence of the buffer appeared to be only slight, the value in the veronal buffer being $1{\cdot}7 \times 10^{4}$ l.mol.$^{-1}$min.$^{-1}$.

The results of Stein and Laidler, given in their Table 2, are obtained at 20·0° C. Unfortunately the *p*H value at which their experiments were carried out is given only as between 7·5 and 8·7. As the influence of the temperature on the inhibition reactions is not very great (I observed apparent activation energy of the order of 10 kcal./mol.) I have assumed that the above-mentioned rate constant is a good approximation of the rate constant under the conditions as given by Stein and Laidler. Using the concentrations of enzyme and DFP as given by Stein and Laidler, I calculated with the above-mentioned rate constant the amount of enzyme inhibition obtained with a reaction time of 10 min., assuming an ordinary bimolecular irreversible reaction and using formula (1).

The results are shown in Table 1, together with the experimentally obtained inhibition values of Stein and Laidler.

When Stein's values are compared with my calculated values striking similarity is seen, especially with the lower DFP concentrations. The fact that with the higher concentrations of DFP the measured inhibition is higher than the calculated values can be explained by the fact, observed by Stein and Laidler, that the addition of substrate (methyl hydrocinnamate) does not stop the inhibition reaction. The results of Stein and Laidler can thus be explained without the assumption of a reversible reaction.

Table 1. Results of Stein and Laidler (ref. 1) compared with Calculated Results from My Experiments. $[E]_0 = 3{\cdot}03 \times 10^{-8}\,M$

DFP × 10^{8}	DFP/$[E]_0$	Percentage of inhibition found by Stein and Laidler	Percentage of inhibition calculated with second order kinetics
1·18	0·39	17·0	16·0
2·36	0·78	28·6	29·5
3·54	1·17	45·1	40·5
4·72	1·56	48·0	51·5
5·36	1·77	61·8	56·5
8·04	2·65	83·2	72·0
10·72	3·54	87·8	82·5

The results with the mixtures of DFP and substrate are certainly not in contradiction of an irreversible bimolecular second-order inhibition reaction.

Concerning the discrepancy between the results of Stein and Laidler[1] and of Jansen *et al.*[2], I calculated the concentration of enzyme used by the latter authors. Assuming a nitrogen content of 15·83 per cent[7] and a molecular weight of 23,000 [8,9] I found that with 0·060 mgm. protein N/ml., the concentration is $1{\cdot}65 \times 10^{-5}\,M$. The reaction conditions of Jansen *et al.* are 25·0° C., 0·2 *M* phosphate buffer *p*H 7·7 and 20 min. reaction-time. With an equimolecular amount of DFP, and again assuming the rate constant $1{\cdot}9 \times 10^{4}$ l.mol.$^{-1}$min.$^{-1}$, I calculated an inhibition of 86·5 per cent, which is certainly much higher than the results of Stein and Laidler. As the concentrations used by Jansen *et al.* are higher and their reaction time longer, the result is not surprising.

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Ammonia Dehydrogenase, Hydroxylamine Dehydrogenase, Hyponitrite Dehydrogenase and Nitrite Dehydrogenase

It has previously[1,2] been reported that there is an enzymatic cycle of inorganic nitrogen. In the present work, we have demonstrated that the dehydrogenating system in the cyclic processes can be separated from the reducing one, and that each dehydrogenase behaves specifically towards different inhibitors. Moreover, the intermediates in the dehydrogenation have been determined quantitatively.

To fractionate enzymes, an acetone preparation was first made from fresh cockerel liver as described in refs. 1 and 2. The precipitate obtained with 33–55 per cent acetone was dissolved in cold water and mixed with 20–30 parts by volume hydroxyapatite as described by Tiselius, Hyertén and Levin[3]. After 1 hr. at 0° C., the suspension was centrifuged at 6,000 r.p.m. for 5 min. The sediment was washed twice with cooled water and extracted with a mixture of sodium acetate and acetic acid. The extract was dialysed against running water for 3 hr. and used as enzyme solution. Measurement of the action of dehydrogenase or reductase was as described in refs. 1 and 2. For comparing the enzyme activity, the value of $-\log T$ was divided by mgm. of protein nitrogen in the reaction mixture. The results are summarized in Table 1.

Table 1. Separation of Dehydrogenases from Reductases

Substrate	0·01–0·1 *M* acetate, *p*H 6·6		2–4 *M* acetate, *p*H 7·5	
	Dehydrogenase activity	Reductase activity	Dehydrogenase activity	Reductase activity
NH_4Cl	0	—	+1·174	—
NH_2OH	+0·038	−3·808	+0·743	−0·090
$Na_2N_2O_2$	0	−4·115	+1·026	−0·101
$NaNO_2$	0	−4·308	+1·166	−0·103
$NaNO_3$	—	−4·000	—	−0·106

The dehydrogenating system was mostly eluted with 2–4 *M* acetate mixture and the reducing one with 0·01–0·1 *M* acetate. Compared with the enzymatic activity of the recentrifuged supernatant from liver homogenate, the dehydrogenases were purified 50–350-fold by these treatments and the reductases 550–750-fold.

In the inhibition tests for the dehydrogenating enzymes, a dialysed 2–4 *M* acetate extract was mixed with *tris*-buffer and inhibitor, and after 20 min. at 30° C., the substrate was added. Some of the results obtained are given in Table 2.

Table 2. Inhibitor Specificity of Dehydrogenases

Inhibitor	Substrate, inhibition (per cent)			
	NH_4Cl	NH_2OH	$Na_2N_2O_2$	$NaNO_2$
Sodium azide, 5×10^{-3} *M*	50	100	0	10
Thiourea, 5×10^{-3} *M*	50	60	20	20
Uric acid, 5×10^{-4} *M*	100	45	85	70
8-Hydroxyquinoline, 5×10^{-4} *M*	100	37	90	0
p-Chloromercuribenzoic acid, 5×10^{-4} *M*	100	0	90	100

It was observed that the dehydrogenation for each substrate is specifically inhibited by certain compounds, indicating that the dehydrogenating system consists of 4 substances.

For estimating the intermediary products in the dehydrogenation process, a larger amount of enzyme and coenzyme, namely, 2 ml. of liver preparation obtained with 33–55 per cent acetone and 8 mgm. of diphosphopyridine nucleotide, were added to the reaction mixture. Ammonia and hydroxylamine were determined by the indophenol method and our modified colorimetry method[4] respectively. It was found that hyponitrite can be estimated by our alkali process[4] for oximes; this was confirmed by using a crystalline salt, $Na_2N_2O_2 \cdot 8H_2O$, prepared according to the description of Jones and Scott[5]. The quantity of nitrite or nitrate was measured by applying Griess's reagent or the 2,4-xylenol method of Buckett, Duffield and Milton[6]. To determine hyponitrite in the reaction mixture containing hydroxylamine, hyponitrite and nitrite, half the mixture was boiled for 5 min. and the other half mixed with 2 volumes of methanol, because boiling for 5 min. decomposes hyponitrite completely but has no influence on the estimation of hydroxylamine and nitrite. After centrifuging, the total amount of hydroxylamine, hyponitrite and nitrite in the mixture treated with methanol as well as that of hydroxylamine and nitrite in the boiled mixture was measured by our alkali process[4]. The results are given in Table 3.

Table 3. Determination of Dehydrogenation Products

Substrate	Amount disappeared (N in μgm.)	Amount produced (N in μgm.)			
		NH_2OH	N_2O_2	NO_2	NO_3
NH_4Cl	32·0	5·1	—	9·5	13·0
NH_2OH	31·8	—	12·6	7·0	8·8
$Na_2N_2O_2$	19·4	—	—	6·5	2·1
$NaNO_3$	20·7	—	—	—	17·5

For the determination of hyponitrite in the hydroxylamine-dehydrogenation, 3×10^{-4} *M* 8-hydroxyquinoline was added to the reaction mixture.

Our experiments have shown clearly that the dehydrogenation and reduction are carried out by different enzyme systems, and our earlier investigation[1] was the first demonstration of such a reducing system in animals. The cyclic oxido-reduction of inorganic nitrogen was also found in yeasts[2]. Klausmeier and Bard[7] reported that di- or triphosphopyridine nucleotide is hydrogenated by *Bacillus subtilis* in the presence of ammonium hydroxide. However, Roussos, Takahashi and Nason[8] proved later that the hydrogenation of pyridine-coenzymes by *B. subtilis* is to be attributed to some factors other than an enzyme specific to ammonium.

The nitrogen cycle formulated by us[1] has been confirmed by these experiments.

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Preparation of Sheep Growth Hormone

Existing methods for the preparation of sheep growth hormone by low-temperature ethanol fractionation[1] or salt fractionation, combined with ion exchange chromatography[2], are lengthy and involve a large number of individual steps. The same criticism applies to existing methods for preparation of ox growth hormone[3,4].

During an investigation of the separation of sheep pituitary proteins on a column of diethylaminoethyl-cellulose (DEAE-cellulose) it was found that under certain conditions all the growth hormone present, in quite simple sheep pituitary gland extracts, passed through the column without adsorption, whereas almost all the other pituitary proteins were adsorbed. Whatman DEAE-cellulose powder (DE60), containing 1·2 milli-equivalents of base per gm. of dry powder, was used in all experiments.

Extracts were prepared by grinding frozen pituitary glands with solid carbon dioxide, and extracting the resultant powder with sodium borate buffer (ionic strength 0·025; *p*H 8·6) for 3 hr. at 4° C. In some experiments these extracts were applied directly to the DEAE-cellulose column. In others the ground glands were extracted with a similar buffer, but to which 0·25 *M* sodium chloride had been added and the extract so obtained dialysed and freeze-dried. The dried material was then dissolved in sodium borate buffer and applied to the column. Both these starting materials contained approximately 0·1 mgm. of growth hormone per mgm. of non-dialysable material, expressed as the equivalent amount of the standard ox growth hormone preparation, *N.I.H. B2* (kindly supplied by the Endocrinology Study Section, National Institutes of Health, Bethesda). The unadsorbed fraction obtained from the column contained 0·6–0·8 mgm. of growth hormone per mgm. of non-dialysable material. This material in 5 per cent w/v concentration was dialysed against distilled water. The resultant precipitate was equal in potency to the *N.I.H. B2* growth hormone and yielded the equivalent of 2·5 gm. of growth hormone per kgm. of fresh glands.

Starch-gel electrophoresis did not show the presence of any proteins other than growth hormone (unpublished observations), but the limits of contamination

with other pituitary hormones, as determined by bioassay methods, has not yet been investigated.

This method for preparing growth hormone uses only very mild conditions and involves a minimum number of steps. It has been applied successfully to the preparation of growth hormone from quantities of fresh, whole glands, ranging from 7 gm. to 200 gm. and using columns containing 20 gm.–150 gm. of DEAE-cellulose. There appears to be no difficulty in extending the method to either smaller or larger quantities of starting material.

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Acute Effect of Three Antibiotics on Diuresis in the Rat

One of the side effects limiting the use of some polymyxins is renal toxicity.

Sodium colistinmethanesulphonate, a new antibiotic with a spectrum of activity very similar to that of the polymyxins, but with much lower systemic toxicity[1], was investigated for its effects upon urinary volume output and was compared in this respect with two polymyxins.

The influence of the administration of each antibiotic upon diuresis was estimated by measuring, after treatment, the urinary output in ml./kgm./hr., 2 and 5 hr. after administration of a water load. This was done in groups of 20 male Wistar rats of approximately 360 gm. which were used twice consecutively in the following manner: first, the normal urinary volume output figures were determined for each group; 2 days later, the same procedure was repeated, each group receiving subcutaneously its respective antibiotic treatment at the same time as the intragastric water load. Each time the rats were starved (food and water) for 18 hr. before intragastric administration of a 50 ml./kgm. tap water load. The animals were then placed in metabolic cages without food and water and their urinary excretion was recorded at 2 and 5 hr., aggregated, and computed as indicated in Table 1.

The results at 2 and 5 hr. indicate that a very marked inhibition of diuresis occurred with all doses of either polymyxin *B* or colistin sulphate up to 1·67 mgm./kgm., whereas doses of sodium colistinmethanesulphonate up to 1·67 mgm./kgm. tended to increase diuresis. However, inhibition of diuresis was observed also with sodium colistinmethanesulphonate at doses above 1·67 mgm./kgm., but it was necessary to administer as much as 16·7 mgm./kgm. in order to obtain a degree of inhibition similar to that noted with 1·67 mgm. of the two other antibiotics. This indicates that, of the three antibiotics tested, sodium colistinmethanesulphonate interferes much less with urinary function, a fact that may explain its higher margin of safety.

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Preparation and Properties of Purified House Dust Allergen

Although house dust allergens have been the subject of many investigations[1], attempts to establish the chemical identity of the specific house dust antigen thus far have met with very little success. This is partly due to the complex nature of crude house dust extracts, which, apart from non-specific toxic substances, contain many other allergens as well (derived from feathers, human and animal dandruff, etc.).

Boatner and Efron[2] were among the first to indicate the general protein nature of active preparations from house dust. Rimington *et al.*[3], in a more detailed study, obtained a purified dust fraction which was found to contain two electrophoretically distinct components of similar chemical composition and skin reactivity. The substance was found to give both protein and carbohydrate reactions. Recently, Vannier and Campbell[4] reported the isolation of a purified dust allergen which they estimated to contain 95 per cent carbohydrate and 5 per cent protein.

Table 1

Control run						Experimental run								
No. of rats		Urinary volume output						No. of rats		Urinary volume output					
		Total (ml.)		ml./kgm./hr.		Treatment (s.c.)	Dose: kgm. (mgm. base)			Total (ml.)		ml./kgm./hr.		Per cent change from the controls		No. of rats with macroscopic peripheral vasodilation
Initial	Final	2 hr.	5 hr.	2 hr.	5 hr.			Initial	Final	2 hr.	5 hr.	2 hr.	5 hr.	2 hr.	5 hr.	
20	20	88	195	5·77	5·14	Polymyxin *B* sulphate	0·29	20	20	52	196	3·51	5·28	−39·2	+ 2·7	0
20	20	113	250	7·55	6·64	.. .. ..	0·50	20	20	5·3	29·9	0·35	0·79	−95·4	−88·1	10
20	20	99	247	6·60	6·58	.. .. ..	1·00	20	20	3·7	10·7	0·25	0·28	−96·2	−95·7	12
20	20	92	245	6·35	6·78	.. .. ..	1·67	20	18	6·4	6·4	0·45	0·18	−92·9	−97·3	20
20	20	96	281	6·33	7·46	Colistin sulphate	1·67	20	20	6·1	31	0·41	0·82	−93·5	−89·0	20
20	20	81	218	5·09	5·49	Sodium colistin-methanesulphonate	0·83	20	20	108	265	6·98	6·83	+ 37·1	+ 26·3	0
20	20	115	233	8·27	6·68	.. .. ..	1·67	20	20	117	285	8·3	8·1	+0·004	+ 21·3	0
20	20	111	242	7·92	6·92	.. .. ..	3·33	20	30	86	216	6·1	6·1	−23·0	−11·8	0
20	20	93	245	6·30	6·63	.. .. ..	6·67	20	20	15	21	1·0	0·56	−84·0	−91·6	20
20	20	87	219	6·09	6·14	.. .. ..	16·7	20	5	6·4	6·8	0·46	0·19	−92·4	−96·9	20

We wish to report the isolation of a purified house dust allergen with high activity in intradermal skin tests, the substance being apparently devoid of non-specific toxic substances and interfering allergens.

1,700 gm. of pooled house dust (collected during September–October, 1960) were extracted with a phosphate buffer $2 \cdot 8 \times 10^{-2}$ *M*, *p*H 7·0, containing $6 \cdot 5 \times 10^{-2}$ *M* sodium chloride and 0·5 per cent phenol. After two days at room temperature, the thick mud was squeezed and the resulting fluid filtered through a 0·5-cm. thick layer of kieselguhr. From the clear, deep-brown coloured filtrate the allergens were obtained by adsorption on benzoic acid at *p*H 4·00, using Sutherland's method[5]. The precipitated benzoic acid was filtered and dissolved in acetone, in which the allergens are insoluble. After washing once with ice-cold acetone, the crude mixture of allergens was extracted twice with the above-mentioned phosphate buffer, the undissolved residue being discarded.

The clear solution was then dialysed in a semi-permeable 'Cellophane' bag against running tap water, followed by dialysis against 0·01 *M* sodium ethylenediamine tetraacetate solution, *p*H 7·00, and distilled water successively. Further purification could be achieved by ammonium sulphate fractionation, the fraction precipitating between 25 and 100 per cent saturation being collected.

This brown-coloured product was dissolved in water and dialysed. The solution was then adjusted to *p*H 3·1 with hydrochloric acid. The resulting precipitate was separated by centrifugation after one day, dissolved in water and lyophilized. Clinical evidence suggests the identity of this product with the human dandruff allergen (Voorhorst[6]). The supernatant at *p*H 3·1 was treated with 4 volumes of acetone. A flocculent pink precipitate formed which was collected by centrifugation, dissolved in water and lyophilized. The yield was 35 mgm.

The substance thus obtained was very easily soluble in water and in physiological salt solutions. Markedly positive reactions were obtained with 2×10^{-5} mgm. (1 : 5,000,000) in intradermal skin tests with patients showing the typical symptoms of house dust allergy. Reagins against this substance could be demonstrated by means of Prausnitz–Küstner passive transfer tests. Controls were always found to be negative.

Paper chromatography of hydrolysates revealed the presence of 12 amino-acids: glu, asp, arg, lys, ser, val, thr, ala, pro, leu, *iso*leu, and cysteic acid. At least three carbohydrates could be detected: galactose, arabinose and xylose. The substance contains 7 per cent nitrogen (micro-Kjeldahl) and 42 per cent hexose (expressed as equivalent glucose in the orcinol test), which suggests it is a mucoprotein, possibly of plant origin. Preliminary ultracentrifugal analysis gave a sedimentation constant of 2·2, indicating a molecular weight of 22 25,000. Further purification was effected on columns of diethylaminoethyl cellulose.

It should be noted that precipitation of the allergen from saturated ammonium sulphate solutions is not complete; after complete saturation, the supernatant still contains about 7 per cent protein (1·4 per cent nitrogen), derived from unprecipitated allergen, as well as a mixture of polyuronides. A similar phenomenon has been reported in the case of trichophytin[7]. A detailed account of this work will be published elsewhere.

Our thanks are due to Prof. L. H. Janson for his interest in this work.

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A New Technique of Chromatography and Ionophoresis on Ion-exchange Paper: Application to the Separation of Barbiturate, Salicylate and Acetophenetidin

We have found that, when a mixture containing barbiturate, salicylate and acetophenetidin is subjected to chromatography on Whatman No. *DE*20 cellulosic ion-exchange paper in dilute ammonia solution, a partial resolution of the components is possible. Salicylate is clearly separated from the other two compounds, which move together with only partial resolution (Fig. 1).

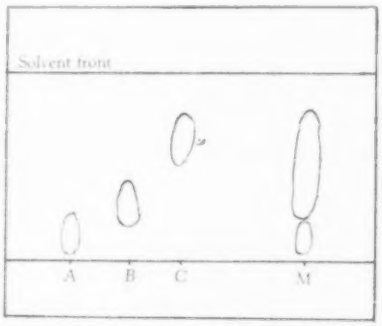

Fig. 1. Ascending chromatography on *DE*20 paper in 0·2 *N* ammonia. Time, 12 min. *A*, salicylate; *B*, phenobarbitone; *C*, acetophenetidin; *M*, mixture of *A*, *B* and *C*

However, if after chromatography the wet paper is subjected to ionophoresis (again in dilute ammonia solution) in a direction at right angles to the chromatographic solvent flow, a complete resolution of all three components of the mixture can be effected in

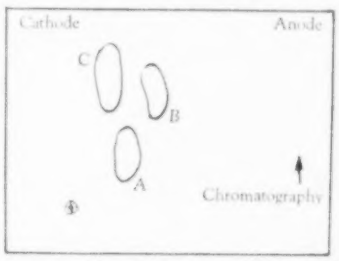

Fig. 2. Ascending chromatography on *DE*20 paper in 0·2 *N* ammonia, followed by ionophoresis for 30 min. in direction at right angles. *A*, *B* and *C*, as in Fig. 1. ⊕, Point of application

only 30 min. (Fig. 2). The chromatography takes only 10–12 min.

By using a micro-electrophoresis tank (Shandon Scientific Co., London), it is possible to carry out the chromatography and the ionophoresis in the same tank with the same solution.

It is interesting to note that when a mixture of salicylate and barbiturate is subjected to ionophoresis on 'ordinary' filter paper, the salicylate moves faster than the barbiturate[1], whereas the reverse is the case with *DE*20 paper. The technique of combining chromatography and ionophoresis on ion-exchange papers may lend itself to rapid separation of mixtures of amino-acids, of mixtures of acids of the Krebs cycle, and of many other mixtures of substances which are either not resolved satisfactorily on paper or which involve conventional chromatography for many hours.

Work is now in progress to develop this technique into a rapid screening test for barbiturates in blood. The technique is also being applied to the separation of alkaloids and other compounds of toxicological interest using different ion-exchange papers. The results of these experiments will be published elsewhere.

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Destruction of Linoleate Hydroperoxide by Soya Extracts

WHEN Balls *et al.* used a thiocyanate assay to estimate oxidation of linoleate by soya lipoxidase, their results suggested that under certain conditions part of the linoleate hydroperoxide produced by the enzyme was afterwards destroyed by crude, but not by purified, enzyme preparations[1]. The reason for this has not been known, although Theorell *et al.* implied that spontaneous decomposition of hydroperoxide might be responsible[2]. Recent work has indicated that there is in crude extracts of soya a factor which destroys β-carotene in the presence of linoleate hydroperoxide[3]. Here, we have examined the possibility that such a factor may also destroy linoleate hydroperoxide enzymically in the absence of β-carotene.

Sumner's thiocyanate assay for peroxide, as modified by Koch *et al.*[4], was used, pure linoleic acid in alcohol solution being added as substrate to *p*H 6·5 phosphate–citrate buffer to give a concentration of $1{\cdot}36 \times 10^{-3}$ *M* in the reaction mixture. Centrifuged dialysed extracts of 1 gm. defatted soya bean meal in 100 ml. water were used as enzyme source, volumes of 0·1–3 ml. being added to 25 ml. of buffer-substrate.

It was found that with small additions of soya extract (0·1–0·5 ml.) there was proportionality of reaction-rate to added enzyme, but that with larger additions (1–3 ml.) hydroperoxide formation was followed by destruction. Results obtained with 2 ml. soya extract are shown in curve *A* in Fig. 1.

Using only 0·3 ml. soya extract, hydroperoxide increase was initially less rapid, but no destruction was observed (curve *B*, Fig. 1) and formation continued steadily up to 80 min. But if a further 2 ml. soya extract were added to the same system at

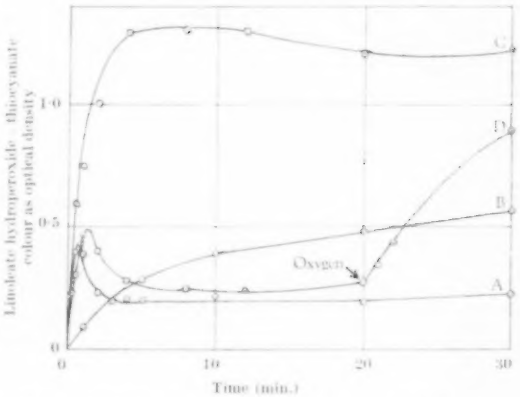

Fig. 1. Formation and destruction of linoleate hydroperoxide. *A*, 2 ml. soya extract; *B*, 0·3 ml. soya extract; *C*, 2 ml. soya extract and oxygenated buffer; *D*, 2 ml. soya extract and oxygen passed in after 20 min.

40 min. from zero time, hydroperoxide destruction, of the same order as shown in curve *A*, resulted. Peroxide destruction did not occur if the 2 ml. soya extract were heated for 3 min. at 80° C. Similar results were obtained when extracts of defatted lentil and of defatted wheat germ (5 gm./100 ml. water) were examined in the same fashion.

These results suggest that the hydroperoxide-destroying factor is enzymic, since it is heat-labile and non-dialysing.

Maier and Tappel[5] have shown that haemoglobin, acting as a catalyst for the decomposition of linoleate hydroperoxide, is only slightly less active than catalase, and much more active than peroxidase or cytochrome *c*. On the system which we have described, added haemoglobin solution had to be at least 5×10^{-5} *M*, with respect to haematin, to destroy as much hydroperoxide as did an equal volume of soya extract. Our soya extracts do not contain enough total haematin to be observed spectrophotometrically as pyridine haemochromogen under conditions where a concentration of 10^{-5} *M* would be obvious, and it may be inferred that if an iron porphyrin compound is responsible for peroxide destruction then its activity in this respect is much higher than those mentioned.

The sudden change from hydroperoxide formation to hydroperoxide destruction may be attributed to exhaustion of available oxygen, since it occurs at a point (Fig. 1) where hydroperoxide, measured as conjugated diene at 232 mμ (assuming an extinction coefficient of 28,000), is $2{\cdot}3 \times 10^{-4}$ *M*. The calculated molarity of dissolved oxygen in the system is about 3×10^{-4} *M*, which suggests that linoleate oxidation ceases because of lack of oxygen, to be succeeded by anaerobic peroxide destruction.

To verify this we repeated the experiment which gave curve *A* in Fig. 1 after first saturating the buffer with oxygen (curve *C*), and alternatively passing in oxygen after the fall in hydroperoxide had occurred (curve *D*). These results confirm the supposition.

It was observed in these experiments that, with small volumes of added soya (0·3 ml.), hydroperoxide formation, calculated from thiocyanate values, was proportional in the early stages to diene formation, but between 2 and 3 times greater. This accords

with observations that thiocyanate methods give results between 2 and 3 times the theoretical[6]. We did not establish this proportionality with larger amounts of soya: with these, when destruction of peroxide occurred, there was no corresponding decrease of diene, suggesting that the products of hydroperoxide destruction remain conjugated. A full account of this work will be published elsewhere.

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Reduction of Coenzyme Q by Succinic Acid Dehydrogenase

It has been pointed out to us that our recent communication under this title[1] could be misunderstood as a claim of having first shown the insensitivity to antimycin A of reduction of ubiquinone. The credit of this observation belongs to Drs. A. M. Pumphrey and E. R. Redfearn[2]. The purpose of our communication was to show that this reduction could be obtained with a non-particulate soluble preparation, simpler than those which have mostly been used hitherto.

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PHYSIOLOGY

Functional Interpretation of Cerebellar Histology

The nature of the transformation of patterns of excitation within the cerebellar cortex may be explained by the following argument, based mainly on histological evidence and on some simple physiological assumptions.

For all vertebrates studied the following facts emerge[1–5]: (*a*) The cerebellar cortex is a sheet of grey substance with anisotropic structure. Entirely different histological pictures are obtained in sections cut in frontal and sagittal planes. (*b*) All output fibres arise from one type of neurons (Purkinje cells) the dendritic fields of which are characteristically flattened in the laterolateral direction. (*c*) One set of input fibres (climbing fibres) is connected one-to-one with the set of Purkinje cells. (*d*) Another set of input fibres (mossy fibres) reaches the output (Purkinje) cells via long (about 5–10 mm.), very thin (about 0·2μ), unmyelinated fibres, the so-called

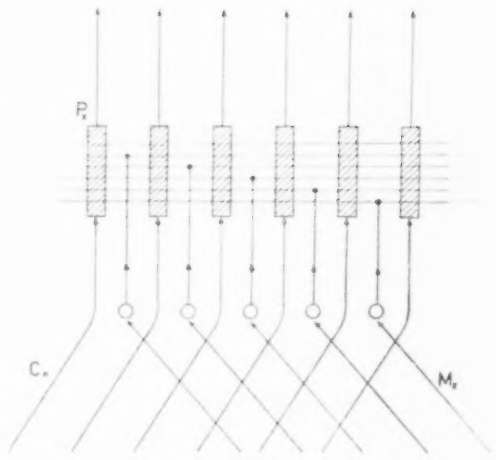

Fig. 1

parallel fibres, oriented exclusively in the laterolateral direction, each making the same kind of histological contacts with a long row of Purkinje cells (about 130 in the human cerebellum). Fig. 1 shows diagrammatically a fragment of such a laterolateral row with incoming and outgoing fibres.

It has been pointed out[5] that the organization of the cerebellar cortex as it appears in sections cut in the frontal plane becomes understandable if interpreted as a specialization for accurate timing of impulses.

Taking into account the well-known relation between diameter of fibres and velocity of conduction, and interpreting the histological connexion of climbing fibres–Purkinje cells as well as that of parallel fibres–Purkinje cells as an indication of synaptic connexions, this histology allows one to predict widely varying delays interposed between the input in one fibre system (the mossy fibres) and the arrival of activity at different laterolateral distances from the point of input, while, on the contrary, the other input system (the climbing fibres) should influence Purkinje cells after a fixed, short time delay.

Direct physiological support for this interpretation is provided in a paper by Calne[6], who found, in the frog, for some sites of stimulation a fixed delay between stimulus and response in the cerebellar cortex, and for other sites of stimulation delays varying between 20 and 260 msec.

Let $P_x(t)$, $M_x(t)$ and $C_x(t)$ be three sets of functions of time with common indices x. We may interpret them as representing activity in Purkinje cells, mossy fibres and climbing fibres of one laterolateral row, such as those in Fig. 1, with x representing the distance of the elements from an arbitrary origin. For convenience I assume all functions to assume only the values 1 and 0, and consider only integral values of x and t, since these simplifications do not significantly alter our argument. Neglecting the short, fixed synaptic delay between climbing fibres and Purkinje cells, our physiological hypothesis becomes:

$$P_{x_0}(t) = f\left[M_x\left(t - \frac{|x_0 - x|}{v}\right), C_{x_0}(t)\right]$$

where v represents the velocity of conduction in parallel fibres which we suppose to be constant. For

a fixed value of C_{x_0}, $P_{x_0}(t) = f\left[M_x\left(t - \frac{|x_0 - x|}{v}\right)\right]$, that is, simply a function of a linear combination of time and place of all $M_x(t) = 1$. Explicitly, we may assume the following dependence:

$$P_{x_0}(t) = 1 \text{ if } \left[\sum_x M_x\left(t - \frac{|x_0 - x|}{v}\right) + C_{x_0}(t) - \Theta\right] > 0$$

and $P_{x_0}(t) = 0$ otherwise, where Θ is a positive integer representing the threshold of Purkinje cells.

This can be used for transforming distances into time intervals and vice versa; in other words, as a clock. Among the many possible modes of operation which suggest themselves I mention only the following examples:

(*a*) Operation as an 'alarm clock'. If $M_{x_0} = 1$ only at t_0 and $C_{x_0 + \Delta x} = 1$ all the time while all other $C_x = 0$, putting $\Theta = 2$, there will be a $P_x = 1$ only at $t_0 + \frac{\Delta x}{v}$.

(*b*) Operation as a 'stop watch'. $M_{x_0} = 1$ only at t_0, all other $M_x = 0$. All $C_x = 1$ only at the unknown time t. There will be only one $P_x = 1$ at t. The distance $|x - x_0|$ will furnish a measure of the unknown time interval $t - t_0$. Again we put $\Theta = 2$.

(*c*) Operation as coincidence and time shift detector. Let $M_{x_1}(t)$ and $M_{x_2}(t)$ be two unknown functions. All other $M_x(t) = 0$ and all $C_x(t) = 0$. We can use $P_x(t)$ with $\Theta = 2$ as coincidence detectors between $M_{x_1}(t)$ and $M_{x_2}(t)$. $P_{x_1 + x_2/2}$ evaluates $M_{x_1}(t) + M_{x_2}(t)$. Other P_x evaluate the two functions shifted in time one with respect to the other, since:

$$P_x = f\left[M_{x_1}(t) + M_{x_2}\left(t - \frac{x_1 + x_2 - 2x}{v}\right)\right]$$

This embodies the principle of cross-correlation between the two functions, with logical product in place of algebraic product. If we sum each $P_x(t)$ over time, we obtain from one row a direct display of something analogous, in the discrete case, to a cross-correlation function of $M_{x_1}(t)$ and $M_{x_2}(t)$.

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Function of Limb Tremor

The collaboration of biologists and engineers has led to a hypothesis concerning the biological function of limb tremor in the frequency-range of 6–15 c./sec.

A target spot of light on a cathode ray tube was moved along a horizontal line into different positions at 1-sec. intervals. An operator was given the task of moving a joystick which controlled the movement of a 'follower' spot of light on the cathode ray tube, in the manner required to bring the 'follower spot' into line with the target spot as quickly and accurately as possible. The manually controlled servo-mechanism was a high-gain positional system with no delays in time between control and display movements.

Records of the target and joystick movements were taken on a high-speed pen recorder. Back-lash in the system set an arbitrary lower limit to the amplitude of limb movements which were recorded. Some observations incidental to the main experiment are reported here.

The records of six experimental subjects were analysed for evidence of a relationship between the limb tremor recorded in the range of 6–15 c./sec. and three different states of the subjects' 'controlling' limb: (*a*) at rest; (*b*) while making the gross rapid movements of primary adjustment; (*c*) while making the fine movements of secondary adjustment. It was found that 80 per cent of all tremor, of amplitude exceeding the measurement threshold, appeared while making the movements of precise secondary adjustment.

The finding reported agrees with much previous information[1]; but a new hypothesis has been formulated concerning the function of the type of tremor described.

Mechanical servo-systems have been designed to maintain small oscillations of medium frequency, that is, the servo 'dither' effect because this 'dither' takes up back-lash in the system and minimizes the break-out forces required to overcome frictional resistances when movements are initiated. Peripheral mechanisms for controlling movement of body limbs (for example, muscle spindles, annulo-spiral nerve-endings and associated loops) bear close analogy to such mechanical servo-systems[2], and it is suggested that limb tremor provides the same advantages as 'servo dither'. The fact that tremor was most marked in the phase of the experiment which necessitated the greatest precision of movement lends support to the hypothesis presented.

The functional analogies which have been suggested between limb tremor and servo dither may be applicable to such similar fine tremor of the eyes and of the head in visual and auditory localization.

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Increased Toxicity of Serotonin in Adrenalectomized Animals

Adrenalectomized rats and mice are more sensitive to anaphylactic shock[1,2], and to the action of histamine[3] and 5-hydroxytryptamine[3,4] which may be involved in the anaphylactic reaction[5], than are intact animals. The toxicity of histamine and of serotonin, as well as anaphylaxis, is increased by the administration of 'pertussis vaccine' and in old and tumour-bearing animals[6]. The present communication reports the toxicity of serotonin in rats and mice in some of these experimental conditions. Sprague–Dawley rats and *ALAL* mice (obtained from the firm ALAL, Milan), of an average weight shown in Table 1, were injected by different routes with 5-hydroxytryptamine-creatinine-sulphate (kindly supplied by Vister Labs, Casatenovo, Como). Adrenalectomy was performed 72 hr. before injection:

Table 1. Toxicity of Serotonin in Various Experimental Conditions

Species	No. of animals	Av. body-weight (gm.)	Experimental condition	Route of administration	LD_{50} (mgm./kgm.)	95 per cent confidence limits
Rat	34	204	Intact	s.c.	> 300	—
,,	210	187	Adrenalectomized 72 hr. earlier*	s.c.	14·5	16·4–12·8
,,	41	151	Intact (young)	i.v.	170	204·0–141·6
,,	41	427	Intact (old)	i.v.	46	61·2–34·5
,,	35	177	Adrenalectomized 72 hr. earlier (young)	i.v.	5·8	6·7–5·0
,,	27	397	Adrenalectomized 72 hr. earlier (old)	i.v.	1·2	1·7–0·9
,,	39	269	Walker carcinosarcoma	i.v.	46	61·2–34·5
,,	28	157	Partial hepatectomy 48 hr. earlier	i.v.	155	217·0–111·0
Mouse	60	10	Intact (young)	i.v.	245	303·8–197·5
,,	38	34	Intact (old)	i.v.	148	198·3–110·4
,,	56	19	Intact (adult)	i.v.	223	285·4–174·0
,,	20	19	Intact (adult)	i.p.	> 600	—
,,	20	19	Intact (adult)	s.c.	> 600	—
,,	67	18	Adrenalectomized 72 hr. earlier (adult)	i.v.	0·9	1·4–0·5
,,	87	19	Adrenalectomized 72 hr. earlier (adult)	i.p.	1·9	4·8–0·7
,,	45	18	Adrenalectomized 72 hr. earlier (adult)	s.c.	19	23·4–15·4
,,	45	21	Sarcoma 180 (adult)	i.v.	95	121·6–74·2

* Adrenalectomized animals were kept drinking saline.

partial hepatectomy—according to the method of Higgins and Anderson[7]—was carried out 48 hr. before, and Walker carcinosarcoma was implanted 15 days before.

The mortality, within 24 hr., was observed. The LD_{50} values in mgm./kgm. are expressed as 5-hydroxytryptamine creatinine sulphate, and confidence limits were calculated by Litchfield's method[8].

In rats a remarkable increase of serotonin toxicity is observed in older animals as compared with young ones. Adrenalectomy increases the toxicity of serotonin in both young and old animals, when given either by subcutaneous or intravenous routes of administration.

In other experiments, not reported in Table 1, it was observed that animals submitted to adrenalectomy 7 and 14 days before carrying out the test were even more sensitive to serotonin than animals adrenalectomized only 72 hr. before.

Partial hepatectomy has no effect on the toxicity of serotonin, and Walker tumour-bearing animals are relatively more sensitive than normal rats.

In mice, age is not such an important factor in serotonin toxicity as in the rat. Adrenalectomy is more effective in mice than in rats in sensitizing to serotonin toxicity. A factor of 29–36 represents the difference between intact and adrenalectomized rats, whereas in mice, when serotonin is given intravenously, this factor is 239. Mice bearing sarcoma 180 are also more sensitive than normal mice to serotonin.

The reasons for the increased sensitivity to serotonin of adrenalectomized animals are under investigation and will be reported elsewhere.

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Some Properties of Rat Mammary Tissue

In 1952 Cross and Harris[1] demonstrated that the degree of milk ejection in a lactating rabbit was dependent on the dose of intravenously injected posterior pituitary extract (pituitrin). A minimal effect was seen after injection of 5 mu. of pituitrin and 200 mu. gave a maximal response. On histological evidence, Richardson[2] had suggested that the myoepithelium was responsible for the expression of milk, and Linzell[3] was able to show that oxytocin caused this milk injection by contracting the myoepithelial tissue surrounding the alveoli. He showed further that acetylcholine, histamine and 5-hydroxytryptamine were all capable of causing such contraction when applied directly to lobules of the mammary glands of lactating mice. However, the milk-ejecting response could be made more specific for oxytocin by using atropine and dibenamine, the concentrations needed to block acetylcholine and histamine respectively having no effect on the response to oxytocin. The use of the milk-ejection response in lactating rabbits as an assay method for oxytocin has been described by van Dyke, Adamsons and Engel[4]. These workers could detect no changes in the intramammary pressure to intravenously injected histamine or 5-hydroxytryptamine, and showed that highly purified vasopressin had approximately 17 per cent of the milk-ejecting potency of pure oxytocin, the comparison being on a unit to unit basis. This was in agreement with work on lactating sows by Whittlestone (1955), but Linzell, comparing the two peptides by the amounts needed to produce threshold responses after topical application to mouse mammary lobules, found oxytocin to be even more potent. Highly purified vasopressin had only 8 per cent of the milk-ejecting potency of an equal unitage of pure oxytocin. This discrepancy might be explained as a species difference or by the different routes of administration used, the intravenous route allowing vasopressin to exert its vasoconstrictor action and so possibly enhance falsely the milk-injecting response. Méndez-Bauer, Cabot and Caldeyro Barcia[5] found that rabbit mammary strips in an organ bath gave graded increases in tension to doses of oxytocin and so it seemed worth while to compare vasopressin against oxytocin on rat mammary strips and, in addition, to investigate the usefulness of the rat mammary strip as an assay tissue for oxytocin. Méndez-Bauer, Cabot and Caldeyro Barcia[5] used sections of lactating

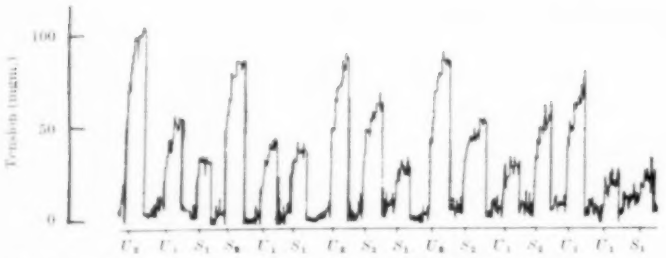

Fig. 1. Graded responses of rat mammary strip to varying doses of oxytocin: S_2, 8 mU.; S_1, 4 mU.; U_2, 10 mU.; U_1, 5 mU.

rabbit mammary glands taken from the nipple up to and including alveoli with associated myoepithelium. In view of the work of Linzell, the rat mammary strips used consisted only of alveoli with myoepithelium and a few small ducts, this tissue being dissected from the lower abdominal mammary glands of a lactating rat anæsthetized with urethane. The Ringer used was that of Edmunds and Cushny[6]; the arginine vasopressin used had been highly purified by the method of Sachs[7]. The oxytocin was supplied by Parke Davis and Co. ('Syntocinon').

To record differences in tension, the mammary strip, suspended in Ringer at a temperature of 37° C. in an organ bath (volume 10 ml.), was attached by a thread to an RCA transducer tube, No. 5734. The transducer acted as a variable resistance in a Wheatstone bridge arrangement. As tension in the muscle increased, the transducer nipple moved slightly, the resistance changed and the current flowing in the circuit was either measured directly on a sensitive micro-ammeter or recorded on paper after amplification. The current flow was directly proportional to the tension exerted on the transducer over the weight range 0–1,000 mgm., and all experimental work was within this tension range.

At the beginning of each experiment the strip was placed under an initial tension of 500 mgm. and the bridge balanced, using an adjustable resistance, so that no current flowed. Doses of oxytocin were then added at approximately 5-min. intervals, the Ringer being changed twice between each addition of oxytocin. Typical responses to four different doses of oxytocin are shown in Fig. 1. To determine the precision of the oxytocin assay, 4 doses, 2 high and 2 low, were chosen. Each dose was given once in any block of four, and one complete assay consisted of 16 responses. A high and low dose was arbitrarily selected as being the solution of 'unknown' concentration and the experimental potency ratio was calculated and compared with the known value. Table 1 shows the results of a series of five such assays.

Table 1. Precision of Rat Mammary Strip Assay Method for Oxytocin

R_t	R_e	E	R_1	R_2	Percentage of fiducial limits $P = 0.05$
1·25	1·26	0·8	1·114	1·434	± 12·7
1·25	1·09	12·8	0·910	1·285	± 17·1
1·25	1·22	3·0	1·100	1·355	± 10·5
1·25	1·25	0·2	1·016	1·542	± 21·0
1·25	1·22	3·0	1·052	1·422	± 15·2

E is the percentage difference between R_t, the theoretical potency ratio and R_e, the experimentally calculated potency ratio. R_2 and R_1 are the upper and lower limits of R_t, calculated for $P = 0.05$.

The mean difference between the theoretical and the calculated potency ratios was 3·9 per cent, and the mean fiducial limit ($P = 0.05$) was 15·3 per cent.

Vasopressin was now assayed against oxytocin on mammary strips taken from rats which had been suckled by large litters (greater than 6) for 1–4 weeks. The age of the litter did not appear to affect the relative potency of vasopressin, which was 3·2 ± 0·24 per cent (9) that of an equal unitage of oxytocin.

Thus, mammary tissue *in vitro* has the advantage of being more specific for oxytocin than the *in vivo* preparation. Rat mammary strips provide an accurate and convenient assay method for oxytocin. Each strip can be used for approximately 3 hr., and one rat kept alive under urethane anæsthesia provides many strips over a long period of time. As described here the method is not very sensitive, 2–4 mU. being needed to produce a small response. Using a 2 ml. bath, 0·5–1·0 mU. would, presumably, give the same response, and should an ultra-sensitive assay method be required, a superfused mammary strip could be used. However, it has often been shown that such highly sensitive assays are of low precision.

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Effect of 9α-Fluoro-11β-hydroxy-17-methyltestosterone ('Ultandren') on the Testis of the Immature Rat

'Ultandren' (Ciba, Ltd.) is known to be an extremely potent oral androgen, approximately ten times as effective as methyltestosterone[1]. In a preliminary investigation of its effects on the testis of the immature rat comparable doses of 'Ultandren' (0·05 mgm.) and methyltestosterone ((0·5 mgm.) dissolved in 0·5 ml. polyethylene glycol were administered daily by mouth for 10 days to litters of rats aged 28–31 days. To a third group of litter mate controls 0·5 ml. of polyethylene glycol was administered daily.

After killing, one testis was removed and fixed in formol saline. Equatorial transverse sections 8μ thick were cut and stained by the periodic acid–Schiff method, with counterstaining by iron hæmatoxylin. This stain accurately depicts the various stages of the spermatogenic cycle[2].

In each testis the number of tubules showing the acrosome phase of spermiogenesis was expressed as a

Table 1

Treatment	Percentage of tubular cross-sections showing acrosome 'phase' of spermiogenesis	Mean percentage
'Ultandren', 0·05 mgm./day	100, 83, 85, 97, 100, 82	91·1 ± 8·71
Methyltestosterone, 0·5 mgm./day	57, 50, 56	54·3 ± 3·79
Control	67, 58, 94, 72	72·8 ± 15·29

percentage of not less than 60 tubular cross-sections observed in 3 non-adjacent testicular sections. The results are indicated in Table 1.

Comparison of the results in control, 'Ultandren'- and methyltestosterone-treated animals shows that with $n_1 = 2$, $n_2 = 10$, $F = 13{\cdot}988$, which is significant at the 0·1 per cent level, thus indicating the heterogeneity of the results of the different treatments.

It is apparent that in 'Ultandren'-treated rats the percentages of tubules showing the acrosome phase of spermiogenesis are higher than in the control animals. This difference is significant ($t = 2{\cdot}34$, $n = 8$, $P < 0{\cdot}05 > 0{\cdot}025$).

When the methyltestosterone-treated and control animals are compared, the testes of the former group show a lower percentage of tubules in the acrosome phase. However, these differences are not significant at the 5 per cent level ($t = 1{\cdot}95$, $n = 5$, $P > 0{\cdot}1 < 0{\cdot}2$).

Although the results using methyltestosterone are not significant it may be a depressor of spermatogenesis in the doses used. 'Ultandren', on the other hand, in approximately equally androgenic doses, accelerates the rate at which the acrosome phase of spermiogenesis is achieved in the tubules of the immature testis. This finding is of interest, since previous workers have been unable to accelerate the normal process of maturation of the testis[3–5]. It is proposed to study the matter in greater detail.

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HÆMATOLOGY

Sensitivity of Hæmoglobin to Oxidation in Various Conditions

When intact red cells are treated with weak solutions of sodium nitrite in isotonic saline, or hæmolysed red cell suspensions are treated with weak solutions of potassium ferricyanide, the red colour changes to brown as the oxyhæmoglobin is oxidized to methæmoglobin. Infants have long been known to be particularly sensitive to this change[1–3]; but it has only recently been shown[3,4] that this increased sensitivity is also present in children of both sexes up to the age of puberty.

Blood samples have been obtained from pregnant women (100), patients with carcinomata (51), other hospital patients (52) and medical and physiotherapy students (100). 96 per cent of pregnancies of more than 6-weeks duration exhibited increased sensitivity of the hæmoglobin to oxidation. A similar, but less-marked, change occurred in the patients with definite carcinomata. Of the other hospital patients only those with acute coronary thrombosis, hæmolytic blood diseases, multiple fractures or severe rheumatoid arthritis showed any deviation from the normal. No case of increased sensitivity occurred in any of the students.

The sensitivity of the hæmoglobin to oxidation rapidly returned to normal after delivery, and, in the few cases so far examined, following complete extirpation of the malignant tumour. The cause of these changes is as yet unknown, and the phenomenon is at present being investigated. The findings will be reported in full elsewhere.

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Experimental Oxidation of Hæmoglobin: its Relation to Growth-rate in Rats

The sensitivity of oxyhæmoglobin to oxidation with nitrites or ferricyanide is increased in children, pregnant women and patients with carcinomata (refs. 1–4 and preceding communication). The change-over from the increased sensitivity of childhood to the adult reaction occurs at about the age of puberty. To investigate the relationship between this reaction and the hormonal changes of puberty, the phenomenon has been studied in rats, as the growth-rate and pubertal changes can be determined and separated much more readily in small mammals than in man.

Rats' hæmoglobin has approximately the same resistance to oxidation as human hæmoglobin and exhibits the same increased sensitivity in the young and pregnant. The growth-rate of some 60 female Lister hooded Worcester sub-strain rats was determined and related to the oxidation sensitivity of their hæmoglobin. Fig. 1 shows that the change-over from the juvenile type of resistance to oxidation occurs at 40–50 gm., which corresponds closely to the time of most rapid change in the growth-rate (40–

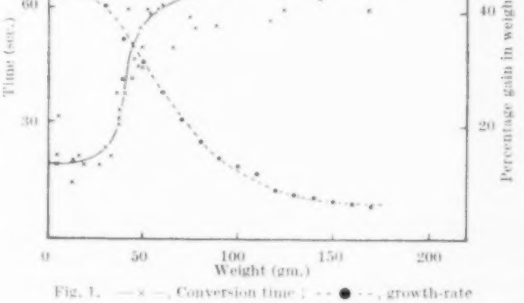

Fig. 1. —×—, Conversion time; - - ●- -, growth-rate

50 gm.). Puberty, in this strain, as judged by vaginal opening, occurs at 100–110 gm.

These findings strongly suggest that the resistance of haemoglobin to methaemoglobinization is more closely connected with changes in growth-rate than with any hormonal change associated with puberty.

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Incomplete Antibodies to Chicken Red Cell Antigens

The evidence supporting the existence of incomplete antibodies to chicken red cell antigens is inconclusive[1], and the following experiments were carried out to see if incomplete antibodies, similar to those against the red cell antigens of man, would be demonstrated:

(1) *Heat inactivation*. Sera containing complete agglutinins were diluted 1/4 and then heated for 10 min. at 70° C. The heated sera were then tested against the appropriate cells in saline, by an albumin replacement technique[2] and by a spin antiglobulin technique using rabbit anti-chicken serum. The results obtained are given in Table 1 (scoring as suggested by Dunsford and Bowley[2]).

Table 1

Serum No.	Specificity	Red cells	Saline	Albumin	Antiglobulin test
244 *B*	anti-*B* 32	*B* 32/32	–	–	F
296 *A*	anti-*B* 38	*B* 38/38	–	–	+ +
242 *A*	anti-*B* 43	*B* 43/43	–	–	+ +
358 *A*	anti-*B* 39 and *B* 41	*B* 32/39	–	–	+ +
380 *A*	anti-*B* 44	*B* 44/46	–	–	+ +
382 *A*	anti-*B* 45 and *B* 46	*B* 46/47	–	–	F
291 *A*	anti-*B* 42	*B* 42/*B* 42	–	–	+ +

(2) *Titration*. Each of the sera of Table 1 was serially diluted, using saline as diluent, and tested against the corresponding cells suspended in saline. The results were read by microscope. The red cells from all the tests giving no agglutination were then well washed four times and tested with anti-chicken serum by the spin antiglobulin technique. The first two positive results of each titration obtained by this method were interpreted as possible enhancement of the reaction of the complete antibody. Any positive results beyond these two were considered due to incomplete antibodies. All seven sera showed this evidence and the results given in Table 2 are typical.

Table 2

Serum 296 *A*	1	5	10	20	40	80	160	320	640	1,280
Saline	*A*	*A*	*A*	*N*	*N*	*N*	*N*	*N*	*N*	*N*
Antiglobulin	Not tested*		*A*	*A*	*A*	*A*	*A*	*A*	*N*	*N*

A, Agglutination; *N*, no agglutination.
* Not tested because agglutination was strong.

(3) Sera were obtained from twelve birds which had been inoculated with red cells to produce specific antisera but, judged by saline agglutination methods, they had not been immunized. Serum from each bird was examined against the corresponding cells by saline, albumin and spin antiglobulin techniques. Four of the sera were found to have incomplete antibodies demonstrable by the antiglobulin technique only. Those sera were also diluted and heated as in the first experiment and re-tested by the antiglobulin technique. The antibodies were still demonstrable, showing them to be thermostable.

These experiments leave no doubt as to the existence of incomplete antibodies to chicken red cells. Fuller details of the methods used, specificity of the antibodies, etc., will be published elsewhere later.

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Circulating Platelets in Mice subjected to Simultaneous X-ray and Ultra-violet Irradiation

The circulating platelet count of mice increases significantly after ultra-violet irradiation. Five to seven days after a single whole-body ultra-violet irradiation the increase is about 100 per cent. Parabiosis experiments, as well as the positive effect of isologous serum transfer, suggested that humoral factor(s) are responsible for the thrombocytopoietic effect and the agent seemed to be a protein-like macromolecule[1] as already described for human serum[2]. In the present experiments we investigated the simultaneous action of whole-body X-ray irradiation, that is, a procedure causing severe thrombocytopenia, and ultra-violet radiation, that is, a procedure causing marked thrombocytosis.

Mice weighing 20 gm. were subjected to ultra-violet irradiation using a Hanau quartz-lamp (no filter, 210 V., 5·2 amp., 50 cm. distance, 30 min.). The dose of whole-body X-ray irradiation was 300 r. (0·5 copper, 180 kV., 10 m.amp., 50 cm. distance). Platelets were counted by a direct phase-contrast microscope method as described by Feissly and Ludin[3]. 0·2 ml. sera from ultra-violet irradiated mice was injected into the tail vein of recipients.

In the first experiments sixty mice were subjected to ultra-violet irradiation and five animals were killed at each interval marked on Fig. 1. The serum of these animals was given intravenously to 5–10 recipient mice in each group. Platelets were enumerated

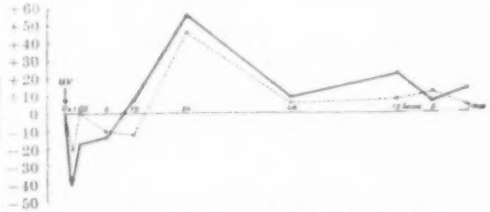

Fig. 1. Circulating platelets in mice injected with the serum of ultra-violet irradiated mouse-groups. – – –, Thrombocytes on the fifth day; ———, thrombocytes on the seventh day

before and 5 and 7 days after serum injections. As shown, the most pronounced thrombocytosis (50–60 per cent) resulted with sera taken 24 hr. after irradiation. Although the platelet count of irradiated animals did not diminish, early serum samples, up to 6 hr. after irradiation, tended to diminish the platelet count of recipient mice.

As Fig. 2 demonstrates, about 60 per cent diminution of circulating platelets followed the 300 r. whole-body X-ray irradiation of mice 10 days later. However, if ultra-violet irradiation was given 24 hr. before this X-ray dose, (*a*) the platelet count did not diminish at all, and an average 21 per cent increase occurred on the tenth day. Furthermore, as demonstrated by (*b*), even ultra-violet irradiation administered 24 hr. after X-rays significantly reduced platelet count diminution.

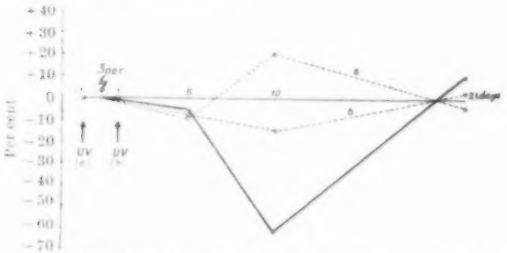

Fig. 2. Circulating platelets in mice subjected to simultaneous X-ray and ultra-violet irradiation. The solid line represents the platelet count of X-ray irradiated animals

In Fig. 3 we see that sera taken from mice treated with ultra-violet irradiation 24 hr. before prevent thrombocytopenia when given 24 hr. after the above X-ray dose (*a*), but cannot prevent thrombocytopenia 5 days after the X-ray injury (*b*).

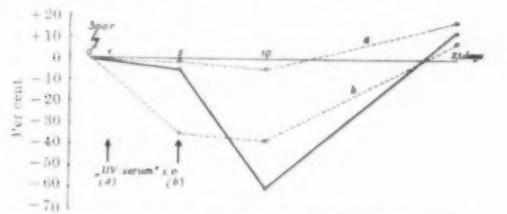

Fig. 3. Circulating platelets in X-ray irradiated mice injected with sera from ultra-violet irradiated mouse-groups. The solid line represents the platelet count of X-ray irradiated animals

X-ray induced thrombocytopenia results from the injury of the megakaryocyte system. It is of some interest, therefore, that the agents which are responsible for the thrombocytosis of whole-body ultra-violet irradiation are effectively present even in mice treated with 300 r. Perhaps these agents do not originate from the bone marrow. On the other hand, the failure of an otherwise effective ultra-violet-light activated serum 5 days after total-body irradiation suggests that the target organ of this thrombocytopoietic factor is the bone marrow.

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RADIOBIOLOGY

Incorporation of Thymidine into Deoxyribonucleic Acid by Extracts from Bacteria exposed to Ultra-violet Light

Ultra-violet light induces a lag in the synthesis of deoxyribonucleic (DNA) acid in *Escherichia coli*[1]. After a dose-dependent incubation interval, the irradiated bacteria will resume synthesis at almost the same rate as prior to exposure. Recently, various investigators[2–4] have shown that blockage of ribonucleic acid (RNA) or protein synthesis prevents the recovery of DNA synthesis in bacteria irradiated with ultra-violet light. The capacity of the bacteria to synthesize DNA after exposure is regained with the initial doubling of RNA in the culture[5].

In this investigation, by measuring ^{3}H-thymidine incorporation into an alkaline-stable, DNAase-sensitive, cold acid-insoluble fraction[6], it has been determined that following exposure to doses of ultra-violet light which inhibit net DNA synthesis *in vivo*, cell extracts showed unimpaired thymidine phosphorylase and DNA polymerase activity. In addition, an increase in activity was noted in the extracts from exposed cells that had been re-incubated in a growth medium. In the system used here ^{3}H-thymidine incorporation into DNA depends on the presence of the other three deoxyriboses in the triphosphate form[6]. This strongly suggests that we are measuring DNA replication rather than thymidine replacement in the pre-formed DNA. Kornberg *et al.*[7,8] and Lehman *et al.*[9] have shown that the polymerase present in a crude enzyme preparation from another strain of *E. coli* is capable of net DNA synthesis.

Cultures of *E. coli* strain *B/r* in the exponential phase of growth were exposed to ultra-violet light from a Hanovia model 30,600 high-pressure mercury vapour arc lamp. The techniques used for radiation exposure, determination of numbers of colony-forming organisms and the measurement of RNA, DNA and protein have been described[10]. The cell suspension at a depth of 1·5 mm. was exposed to 980 ergs per mm.^{2} ultra-violet light while being stirred vigorously. The cells were broken in a French pressure cell to yield the extracts tested[6]. By centrifugation at 10,000*g* for 20 min., a pellet of intact cells and cellular debris was formed. The resultant extracts contained less than 10^3 colony-forming bacteria per mgm. protein.

This dose of ultra-violet light does not decrease the activity of the thymidine-incorporating enzymes found in the extracts from the exposed cells (Table 1). This exposure is effective in delaying *in vivo* synthesis of DNA for a period of 75 min. Furthermore, during this period, in which synthesis of DNA is blocked, a considerable increase in RNA, protein and the thymidine-incorporating enzymes is observed. Additional experiments with higher doses of ultra-violet light have shown that exposures sufficient to reduce survival as low as 0·1 per cent do not diminish the capacity of extracts from such cells to incorporate thymidine into DNA.

If the enzymatic activity present in the extracts reflects the enzyme content of the intact cells, then these results indicate that the blockage of synthesis of DNA by ultra-violet cannot be ascribed to an effect on the polymerase or the enzymes responsible for phosphorylation of thymidine. These results are comparable to those of Billen, who determined that

Table 1. Effect of Ultra-violet Light on Survival and Synthesis of Nucleic Acids and Protein by *Escherichia coli* Strain B/r and on the ^{3}H-Thymidine-Incorporating Capacity of Bacterial Extracts

Ultra-violet exposure (980 ergs/mm.^{2})	Incubation time (min.)	Intact bacteria				Extracts	
		RNA μgm./ml.	DNA μgm./ml.	Protein μgm./ml.	Colony-forming bacteria/ml.	^{3}H-thymidine incorporation*	Relative enzymatic activity†
—	0	25·2	5·4	82·9	$2·5 \times 10^8$	99	400
—	0	23·2	5·0	80·8	$4·6 \times 10^7$	87	440
+	30	28·0	5·2	107·0	$6·0 \times 10^7$	134	550
+	60	32·6	5·2	125·8	$4·7 \times 10^7$	181	430

* μμmoles of ^{3}H-thymidine incorporated in 20 min. The extract used per reaction vessel is equivalent to 4 ml. of the bacterial suspension

† μμmoles of ^{3}H-thymidine incorporation into DNA per mgm. of extract protein.

extracts from cells lacking a component of the DNA synthesizing system because of amino-acid starvation[11] possessed enzymatic activity for DNA synthesis *in vitro* equivalent to cells fully capable of DNA synthesis[6]. It seems clear that the blockage of DNA synthesis, either by ultra-violet light or amino-acid starvation, cannot be ascribed to an effect on DNA polymerase *per se*. While the possibility exists that the extraction procedure may remove the enzymes from some inhibitory effect of the ultra-violet light, this possibility seems less likely in the case of the enzymes synthesized after exposure to ultra-violet light. Thus, at 60 min. incubation, the enzymatic activity in the extract has doubled while DNA synthesis *in vivo* remains blocked for an additional 15 min.

Though these investigations have not measured the activities of the kinases of the nucleosides other than thymidine, it seems unlikely that the blockage of DNA synthesis by ultra-violet light can be ascribed to an inhibition of synthesis of any of the deoxyribonucleotides, since Kanizir and Errera[12] found extensive accumulation of deoxyribonucleotides *in vivo* following exposure to ultra-violet light. Rather, it would appear that we must ascribe the ultra-violet light block to an effect on some other component of the *in vivo* DNA-synthesizing system which is restorable through RNA and protein synthesis following exposure. In view of the results of Doudney and Haas[5], which relate ultra-violet-induced mutation to the restoration of this component of the DNA-synthesizing system, it may be predicted that the component plays an intimate part in the transfer of genetic specificity from parental to daughter DNA.

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Nitrogen Protection of Fecundity and Fertility in Female *Habrobracon* treated with X-rays

Braconid anoxia experiments were performed as a logical sequel to investigations with ingested chemical protectors[1]. In both cases, damage was assessed by scoring the eggs produced per unit of time and the larvæ emerging therefrom. Eggs are dispensed in exact order from the single developmental series identical for each of the four ovarioles. This feature makes it possible to correlate quantitative modifications in the number of eggs, and their hatchability, with the cellular state at the time of irradiation.

Cysteine or glutathione fed to female *Habrobracon* prior to irradiation protected a significant fraction of the cells which afterwards gave rise to the eggs laid toward the end of the first week and at the beginning of the second[1]. At the time of exposure the cells involved were mitotically active and engaged in transition from oogonia to differentiated trophocyte–oocyte units. According to a widely accepted hypothesis, the sulphydryl types of protective compounds operate by reducing the availability of oxygen in irradiated cells. The present experiments were carried out to determine whether anoxia by gas replacement would protect only the mitotically active cells or whether protection could be extended to all the cell types present in the wasp ovariole.

The virgin females used were isolated from stock No. 33 (Whiting) of *Habrobracon juglandis* = *Bracon hebetor*. Groups of 15 were irradiated in the small plastic chambers developed during the examination of gas modification of radiosensitivity of developing *Habrobracon*[2]. In gas replacement experiments nitrogen was passed through the chamber for two minutes before sealing. Including two minutes of such flushing, the wasps were in nitrogen for a total of 15 min. X-rays were delivered by the Woods Hole Marine Biological Laboratory generator, which operates at 28 m.amp. and 200-kV. peak with filtration equivalent to 0·2 mm. of copper.

Exposures in both air and nitrogen were made at 2,250 r. and 4,500 r. A higher series of doses ranging from 9,000 r. to 13,600 r. were delivered in nitrogen. An unirradiated group given nitrogen for 15 min. demonstrated that such treatment did not decrease egg production.

A nitrogen atmosphere afforded nearly complete protection from the 2,500 r. dose. Except on days 3, 4, and 5 egg production was not significantly lower than controls. In fact, on a majority of days control values were exceeded. Fig. 1 presents egg production after higher doses selected for contrast and comparison. 4,500 r. delivered in air is near the threshold for permanent infecundity[3]; but if delivered in nitrogen is found to be much less effective. Indeed, during the latter part of life, egg production compares well with

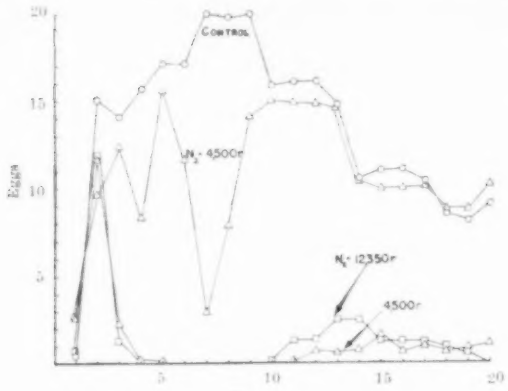

Fig. 1

control values. The eggs deposited during this period are derived from cells which were oogonia at the time of treatment.

The nitrogen series provided a family of curves demonstrating that low egg production equivalent to that following 4,500 r. in air is attained between 12,350 and 13,600 r. Records for the former are shown in Fig. 1. The higher dose resulted in only scattered eggs on the 12th to 14th days. For the sake of clarity the family of curves obtained in the nitrogen series is not shown in the graph. In a regular expected order they would fill in the space between the 4,500 r. and the 12,350 r. curves.

A summary of hatchability for the eggs of Fig. 1 is shown by Table 1. The basis of comparison reflects cytological conditions of the developing units at the time of irradiation. Protection afforded by the replacement of air by nitrogen is apparent not only in a significantly higher hatchability after 4,500 r. but also in hatchability which approaches control values after the eleventh day. Standard errors range from 1 to 3 per cent. Hatchability records for the 12,350 r. nitrogen experiment are included as a demonstration that larvæ are obtained from eggs laid during both the decline phase and recovery phase of egg production. No exactly comparable data are available.

These results demonstrate that the protective effect of gas replacement anoxia is afforded to all types of cells in the polytrophic ovariole. They comprise differentiated, transitional and primitive cells. The progress of meiotic prophase, mitosis, and interphase characterizes the respective periods, with mitotic activity explaining the radiosensitive 6–10 day period. Limitation of protection by SH compounds to the sensitive period might indicate merely a selective concentration of the chemical substances and localized reduction of oxygen availability. Alternatively, the present results would raise the question of whether reduced oxygen is the explanation of sulphydryl protection. This alternative is an interesting possibility in view of the recent demonstration that the mode of action of cysteine includes one reaction that can occur independently of oxygen[4].

Table 1. Percentage of Hatchability for Eggs of Fig. 1. 5-Day Periods refer to the Cytological Condition of the Cells at the Time of Irradiation from which Eggs may afterwards be obtained during the Periods indicated

X-ray	Gas	Days after irradiation			
		1–5	6–10	11–15	16–20
None	Air	93·2	95·1	91·8	85·6
4,500 r.	N_2	79·9	74·6	90·7	80·3
	Air	65·2		14·4	52·7
12,350 r.	N_2	51·3		40·2	9
Cytological stage when irradiated		Oocytes	Transitional cells	Oogonia	Oogonia (senility)

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Reversal of γ-Ray-induced Dormancy of Potato Tubers by Gibberellic Acid

Potatoes (var. Up-to-date), which were free from sprouting, were packed in polyvinyl chloride bags and irradiated with 8,000 and 12,000 rads of γ-rays during a 'shut-down' period of the swimming-pool-type reactor *Apsara*. The dose-rate during the period of irradiation was 200 rads/min. Based on a sample of 81 potatoes in each case, the numbers sprouting, 35 days after irradiation, were 81 % control, 9 with a dose of 8,000 rads and none with a dose of 12,000 rads.

γ-Ray-treated potatoes were dipped for 5 min. in 250 and 500 p.p.m. solutions of sodium salt of gibberellic acid, 35 days after irradiation. In the case of potatoes irradiated with 8,000 rads, only those free from sprouting were chosen for treatment with gibberellic acid. The control potatoes were dipped in distilled water for 5 min. The results are recorded in Table 1. In the potatoes treated with 8,000 rads of γ-rays, 20 out of 20 potatoes sprouted in 10 days with 500 p.p.m. and in 15 days with 250 p.p.m. of gibberellic acid. Similarly, in the case of potatoes that had received a dose of 12,000 rads of γ-rays, 20 out of 20 potatoes sprouted in 15 days with 500 p.p.m. and in 20 days with 250 p.p.m. of gibberellic acid.

As a result of irradiation with 8,000 and 12,000 rads of γ-rays, the buds on the potatoes degenerated. Similar degeneration of potato buds as a result of γ-irradiation has been observed by other workers[1,2] also. In the present experiment, new buds arose

Table 1. Effect of Gibberellic Acid on the Reversal of γ-Ray-induced Dormancy of Potato Tubers stored at 23–32° C. (Relative Humidity, 75–95 per cent)

Treatments (γ-radiation in rads : gibberellic acid in p.p.m.)	No. of tubers	No. sprouting after, days			
		5	10	15	20
(1) 8,000 : 0·0	20	Nil	Nil	Nil	Nil
(2) 8,000 : 250	20	7	16	20	20
(3) 8,000 : 500	20	13	20	20	20
(4) 12,000 : 0·0	20	Nil	Nil	Nil	Nil
(5) 12,000 : 250	20	5	12	17	20
(6) 12,000 : 500	20	8	14	20	20

adjacent to those degenerated after treatment with gibberellic acid.

It appears that γ-irradiation impairs a possible endogenous gibberellin-synthesizing system in the potato and that the effects of this damage can be counterbalanced by exogenous gibberellic acid.

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Incorporation of Phosphoryl-choline labelled with Phosphorus-32 into the Liver Phospholipids of Rats treated with Growth Hormone

The rate of incorporation of acetate labelled with carbon-14 into the liver phospholipids of rats treated with growth hormone is reduced to about 50 per cent of that found in normal animals[1]. On the other hand the rate of incorporation of orthophosphate labelled with phosphorus-32 in similarly treated animals is increased by about 30 per cent[2]. It thus appeared that growth hormone might affect the rates of synthesis of the fatty acid skeleton and the phosphoryl-base moiety separately.

Adult female rats were injected with 1 mgm. pituitary growth hormone 6 hr. before killing. The rats were killed and the livers rapidly excised and slices cut on a Stadie–Riggs microtome[3]. 400 mgm. slices were incubated for 3 hr. in 5 ml. Krebs–Ringer bicarbonate (gassed with 95 per cent oxygen–5 per cent carbon dioxide) in the presence of either 0·5 μc. $H_3{}^{32}PO_4$, glycine-2-^{14}C or sodium acetate-1-^{14}C. At the end of the incubation the slices were collected and homogenized in 5 ml. 5 per cent trichloroacetic acid. The phospholipids were separated, plated and counted as described previously[1]. The results of such an experiment are given in Table 1.

It will be seen that, on the basis of specific activity, there is no change in the rate of incorporation of either orthophosphate or glycine, but acetate incorporation is greatly reduced. However, in view of the massive mobilization of lipids to the liver[4], the values for the specific activities are not as meaningful as the total counts incorporated, also given in Table 1. From these it will be seen that there is a reduced rate of incorporation of acetate, but an increased incorporation of phosphate and glycine which fully confirms the previous results. Because there is a strong possibility that the phospholipins as extracted above might be more or less contaminated with phosphatidic acids, the phospholipids obtained were further purified by adsorption chromatography by Kennedy's method[5]. The results obtained with this purified material were the same as those already described.

Since the glycine is only incorporated into the base of phospholipids[6], it would thus appear that both the phosphate and the base are incorporated more rapidly in the hormone-treated animals than in the controls. Since this could be due either to a more rapid rate of formation of phosphoryl-base or, alternatively, to a more rapid incorporation of the phosphorylated base into phospholipin, we have investigated the incorporation of phosphoryl-choline into the liver phospholipids of normal and growth hormone-treated animals.

Phosphoryl-choline labelled with phosphorus-32 was prepared according to Riley's method[7], and calcium ion was removed by use of an exchange resin '*IR*-120' (K^+ cycle). The rats were injected as above and the livers removed. A 'particle fraction', prepared according to Kennedy[8], was used for the incorporation experiments. The incubation period was 1 hr. The phospholipids were extracted and purified according to Kennedy[8] and counted as before. The results are given in Table 2.

In each of the three experiments the phosphoryl-choline was incorporated into the phospholipids of the injected animals at a rate about one-third greater than in the control animals, that is, at about the same rate as the incorporation of phosphorus and glycine.

To account for these results two explanations may be advanced: (1) that there exists a smaller pool of phosphoryl-choline in the livers of the injected animals; (2) that there is an increased rate of phospholipin synthesis in the livers of the hormone-treated animals. In this second case the very much lower rate of incorporation of acetate in the injected animals may be accounted for in terms of the inhibition of some step between acetate and diglyceride, or alternatively to a dilution of the diglyceride pool in the livers of growth hormone-treated animals. It has already been suggested that the incorporation of

Table 1. Effect of Pituitary Growth Hormone on the Incorporation of Orthophosphate-^{32}P, Glycine-2-^{14}C and Acetate-1-^{14}C into Phospholipids of Rat Liver Slices

Precursor	Specific activity (counts/100 sec./mgm.)			Total incorporation (counts/100 sec./flask)		
	Hormone-treated	Control	Treated × 100 / Control	Hormone-treated	Control	Treated × 100 / Control
Orthophosphate-^{32}P	1,024	1,042	98	8,735	6,731	130
Glycine-2-^{14}C	969	977	99	8,266	6,311	131
Acetate-1-^{14}C	139	805	17	1,186	5,200	23

Table 2. Effect of Pituitary Growth Hormone on the Incorporation of ^{32}P-Choline into the Phospholipids of Rat Liver 'Particles'

Exp.	^{32}P-Choline added (μmoles/flask)	^{32}P-Choline incorporated (mμmoles/flask)		
		Growth hormone-treated	Control	Treated × 100 / Control
I	4	6·3	4·6	137
II	18	12·3	9·5	129
III	20	21·6	14·1	153

Each flask contained initially 100 μmoles of phosphate buffer, pH 7·4, 10 μmoles ATP, 1·5 μmoles CTP, 20 μmoles $MgCl_2$, ^{32}P-Choline (33,700 c.p.m. per micromole) as indicated and 'particles' derived from 0·4 gm. liver. 1·5 μmoles of ATP and 0·03 μmoles of CTP were added every 12 min. during the course of the experiment. The flasks were incubated at 37° C. for 1 hr.

acetate into fatty acids is greatly reduced in growth hormone-treated rats[1] and experiments are now in progress to establish whether there is another block between fatty acids and diglycerides and whether there is a dilution of the diglyceride pool.

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PATHOLOGY

The Liver in Infective Hepatitis

The changes in the liver during the acute stage of infective hepatitis consist of marked alterations to the liver cells, especially in the central regions of the lobule, and an infiltration of the portal tracts and sinusoids with inflammatory cells. Except in fatal cases, necrosis of liver cells is infrequent[1–4]. The disease is thought to be a virus infection of the hepatic parenchyma; but the causative organism or organisms have so far eluded laboratory isolation[5].

This communication reports the results of work on 26 needle biopsies which have been carried out on the livers of African soldiers suffering from infective hepatitis. Biopsies were performed between 5 and 73 days after the onset of disease. For comparison, liver biopsies have also been performed on healthy human volunteers. Liver specimens have been studied by a variety of cytological and cytochemical methods and by electron microscopy after conventional osmium fixation and methacrylate embedding.

Histological examination of the infective hepatitis livers showed the typical parenchymal and stromal changes of this disease. Although the sequence of liver cell alterations could not always be accurately determined, the earliest change, as shown by light microscopy, appears to be enlargement of the nucleolus and a concurrent increase in ribonucleoprotein. This increase in ribonucleoprotein is progressive, and later results in marked enlargement and distortion of the nucleolus. The nucleus also becomes swollen; but an increase in nucleoprotein has not been detected in the nucleoplasm. While these changes are taking place, the cytoplasm shows a progressive increase in ribonucleoprotein which commences in the region of the nucleus but later fills most or all the cell. Cytochemical tests indicate that this newly formed ribonucleoprotein contains the amino-acids, arginine, typtophan and tyrosine, and small amounts of cysteine and cystine. It does not contain deoxyribonucleic acid.

In some cells the mitochondria show variable degrees of swelling; in others they appear increased in number. The Golgi complex is clearly seen in healthy biopsies, but because it is not demonstrable in infective hepatitis livers it is thought to have undergone degeneration.

Fig. 1. Periphery of liver cell showing numerous roughly spherical bodies in the cytoplasmic matrix. (× 23,700)

Electron microscope studies on 14 infective hepatitis livers reveal marked cell changes in all cases. In some instances the nucleoplasm exhibits an increased amount of granular material and the nucleoli are often distorted. Within the cytoplasm the endoplasmic reticulum is usually dilated, and the mitochondria are often grossly swollen. In some cells, however, the mitochondria are increased in numbers, fresh forms arising from existing mitochondria. Not infrequently the microbodies are increased also. The cytoplasmic matrix of some liver cells contains numerous granules which measure approximately 21·5 mμ in diameter and, therefore, are larger than the ribonucleoprotein-containing granules of healthy cells. Often 6–12 of these granules appear to be aggregating to form irregularly spherical bodies measuring 76–103 mμ in diameter (Fig. 1). Such spherical bodies were seen in 7 of the 14 infective hepatitis livers but in none of 6 healthy livers. In one case they were present 29 days after the onset of disease. The bodies are always confined to the cytoplasmic matrix, but occasionally they appear to be passing from the liver cells into the sinusoids and are present in the blood serum. Spherical bodies, varying between 30 and 70 mμ, have already been visualized in the cytoplasm of liver cells in infective hepatitis[6,7].

Although it has not been possible to determine accurately the progression of liver cell changes in infective hepatitis, it is thought that it parallels the sequence of alterations which occur in the liver cells of rhesus monkeys infected with yellow fever[8]. In this latter condition there is an increased synthesis of ribonucleoprotein in the nucleolus. The newly formed ribonucleoprotein passes in a finely granular state through the nucleoplasm to the cytoplasmic

matrix. In the matrix the granules aggregate to form small rosettes which later contract to give rise to spherical virus particles. Although further on infective hepatitis is required before the true nature of the spherical bodies is elucidated, it is considered on the basis of present evidence that they may possibly represent the causative virus.

More detailed reports on the liver in infective hepatitis are to be published later.

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Precipitation Reaction between Serum and Lysed Erythrocytes

Human serum reacts with haemolysates of human erythrocytes to form a precipitate; this occurs even with the isologous haemolysate. When the haemolysate is added to serum in tubes at 37° C., precipitation continues for several days. In agar-gel, using a double diffusion technique, a well-marked precipitate band is formed (Fig. 1). Peetoom *et al.*[1] described a precipitate of this type in agar-gel, but only minimal precipitation in fluid media. In spite of antigenic differences between adult and foetal haemoglobins[2], serum and haemolysate from adult and umbilical cord blood form precipitates in agar-gel, which are qualitatively the same. Cross-precipitation also occurs between human and some animal sera and haemolysates. As the reaction is of general occurrence, it causes false positive results in tests for auto-antibodies when the tissue extract used as antigen contains sufficient lysed erythrocytes.

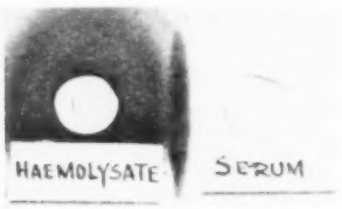

Fig. 1. Precipitate band formed by double diffusion of serum and haemolysate in agar-gel

The precipitate forms with serum and haemolysate from blood of the same or different *ABO* blood-groups. After absorption of the α- and β-antibodies with intact erythrocytes, serum continues to form the precipitate. The cell envelope is not involved, as precipitation occurs with Seitz-filtered haemolysates. Thus, the reaction is independent of the *ABO* groups.

Although haptoglobins were not detected by Tuttle[3] in cord blood, serum from cord blood gives a precipitate with adult and cord haemolysates. Also adult serum, after absorption for 3 days at 37° C. with haemolysate containing 8–12 mgm. haemoglobin per ml., loses its ability to precipitate with haemolysate in agar-gel; but Allison *et al.*[4] found that the haptoglobins in 1 ml. of serum could react with only 1·35 mgm. of haemoglobin. Therefore, serum factors other than haptoglobins must be involved.

The reaction titres of sera from normal adult and cord blood, tested in agar-gel, are similar; but some sera from cases of haemolytic disease of the new-born and of acute haemolytic anaemia have reduced titres. Thus, this precipitation reaction may be part of the physiological mechanism for the removal of products of erythrocyte lysis.

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Antigenicity of Deoxyribonucleic Acids from Mouse Liver and from the Ehrlich Ascites Tumour

In recent years, a number of reports have appeared concerning the antigenicity of mammalian and bacterial deoxyribonucleic acid. Evidence has been presented indicating that complement-fixing[1] and precipitating[2] antibodies may be produced by the injection of such preparations into experimental animals. In addition, serum from patients with systemic lupus erythematosus has been shown to react immunologically with highly purified deoxyribonucleic acid from a variety of sources[3]. The present communication concerns the production of antisera by the immunization of rabbits with deoxyribonucleic acid preparations isolated from mouse liver and from cells of the Ehrlich ascites tumour. The results obtained indicate that anti-tumour cell deoxyribonucleic acid serum has an inhibitory effect on the growth of the tumour *in vivo*.

Mouse liver and Ehrlich tumour cell deoxyribonucleic acids were isolated by the detergent method of Kay, Simmons and Dounce[4]. The preparations had nitrogen/phosphorus ratios of 1·65–1·68. In the analytical ultracentrifuge (Spinco, model *E*) equipped with an ultra-violet optical system, solutions containing 25–30γ DNA/ml. in 0·2 *M* potassium chloride – 0·01 *M* phosphate buffer, *p*H 7·0, were found to contain components having sedimentation velocities ranging from 20 to 40 Svedberg units, with mean sedimentation velocities of 24–25 *S*. Contamination with polypeptide material was minimal. One-dimensional paper chromatography of hydrochloric acid hydrolysates of the deoxyribonucleic acid (using methyl ethyl ketone/glacial acetic acid/water, 2:1:1, as solvent) revealed the presence of amino-acids with the R_F values of leucine (0·04–0·08 per cent), methionine (0·02–0·04 per cent), glutamic acid (0·008–0·016 per cent), arginine (0·01–0·02 per cent) and

lysine (0·02–0·06 per cent). Polysaccharides containing hexosamine could not be detected by the Rimington[5] modification of the method of Elson and Morgan[6]; that is, if such substances were present they represented less than 0·01 per cent of the nucleic acid preparations.

Antisera were produced in rabbits (New Zealand whites) either by the intravenous injection of solutions of the deoxyribonucleic acids in physiological saline or by the intramuscular injection of the nucleic acids suspended in Freund's adjuvant. In the first case (pool 1), each rabbit received 4·0 ml. of deoxyribonucleic acid solution (containing 3 mgm./ml.) twice weekly for a total of eight injections. In the second case (pool 2), each rabbit was injected twice-weekly for a total of eight injections with 4 ml. of antigen suspension containing 2 mgm. deoxyribonucleic acid per ml. Rabbits were bled by cardiac puncture two weeks after the final injection. In each case, the sera from three immunized rabbits were pooled before testing. Normal rabbit serum was obtained from the same rabbits prior to immunization.

The two methods of immunization yielded antisera of much the same potency. In complement fixation tests, performed by a slight modification of the Kolmer–Boerner technique[7] employing 250γ antigen per tube, complete fixation was observed with serum dilutions of 1 : 128 to 1 : 256. Illustrative results are presented in Table 1. Although the antisera appeared to react somewhat more extensively with the homologous than with the heterologous antigen (with the exception of the reaction between anti-mouse liver DNA serum and DNA isolated from the *AH*130 rat ascites hepatoma) the results in Table 1 do not permit one to make a case for their specificity.

Table 1. Complement-Fixation Tests with Sera from Rabbits Immunized with Deoxyribonucleic Acid Isolated from Mouse Liver and from the Ehrlich Ascites Tumour

Serum	Antigen*	Complement-fixation titres†
Anti-Ehrlich DNA, pool 1	Ehrlich DNA	128
	Mouse liver DNA	64
Anti-liver DNA, pool 1	Ehrlich DNA	64
	Mouse liver DNA	128
Anti-Ehrlich DNA, pool 2	Ehrlich DNA	256
	Mouse liver DNA	128
Anti-liver DNA, pool 2	Mouse liver DNA	128
	*AH*130 rat hepatoma DNA	128
	6C3*HED* lymphosarcoma DNA	32
	DBA lymphoma DNA	64

* Concentration employed in complement-fixation test = 250γ/tube.
† Expressed as reciprocal of serum dilution showing complete fixation of complement.

Investigations of the effects of the antisera on the growth of the Ehrlich ascites tumour in mice do suggest, however, that the antisera have some measure of specificity. The antisera were tested in the following manner for their ability to inhibit tumour growth. The cell concentration in a pool of ascitic fluid was adjusted to the desired value (40 or 80 × 10^6/ml.) by the addition of Hanks's balanced salt solution. Aliquots of this cell suspension were mixed either with equal volumes of the antisera or with normal rabbit serum. Mice were injected intraperitoneally with 0·25 ml. (2·5 or 5·0 × 10^6 cells) of the resulting cell suspensions. In each experiment, mice injected with cell antiserum mixtures were divided into two groups. One group received no further treatment; mice in the second were injected with antiserum subsequent to tumour implantation according to the schedule indicated in Table 2.

Table 2. Effect of Antisera produced in Rabbits against Ehrlich Ascites Tumour and Mouse Liver Deoxyribonucleic Acids on the Growth of the Ehrlich Tumour in Mice

Antiserum	No. of cells implanted	Survivors	Mean survival time (days)	*P*§
Normal rabbit serum	5 × 10^6	0/10	16·4	
Anti-liver DNA (pool 1)*	,,	0/10	16·0	0·7
,, †	,,	0/10	17·3	<0·6, >0·5
Anti-Ehrlich DNA (pool 1)*	,,	2/10	24·5	<0·001
,, †	,,	5/10	24·2	<0·01, >0·001
Normal rabbit serum	5 × 10^6	0/10	15·4	
Anti-liver DNA (pool 1)*	,,	0/10	15·8	<0·9, >0·8
,, †	,,	0/10	16·2	<0·7, >0·6
Anti-Ehrlich DNA (pool 1)*	,,	0/10	19·0	<0·05, >0·02
,, †	,,	2/10	27·5	<0·001
Normal rabbit serum	2·5 × 10^6	0/10	15·9	
Anti-liver DNA (pool 2)*	,,	0/10	20·6	<0·02, >0·01
,, ‡	,,	0/10	27·6	<0·001
Anti-Ehrlich DNA (pool 2)*	,,	0/10	25·8	<0·001
,, ‡	,,	7/10	31·7	<0·01, >0·001

* No post-tumour implantation therapy.
† 0·25 ml. serum injected intraperitoneally 24 and 72 hr. post-tumour implantation.
‡ 0·50 ml. serum injected intraperitoneally 24 hr. post-tumour implantation.
§ Probability of mean differing from that of controls by chance alone calculated by the *t* test.

The results of these experiments are summarized in Table 2. Antiserum against mouse liver DNA was without significant effect on tumour growth. Of sixty mice injected with Ehrlich cells suspended in this anti-serum, sixty developed and died of the ascites tumour; and in only one of three experiments was there a significant increase in mean survival-time compared with the control group. In contrast, mice which died with ascites following injection with cells plus anti-Ehrlich DNA serum showed in every case a significant increase in mean survival-time compared with the control group. More significant was the fact that, of thirty mice in this category which received some post-tumour implantation therapy, fourteen survived without evidence of tumour development, either in ascites or solid form, during the observation period of sixty days.

These results provide evidence that highly polymerized DNA is antigenic in the rabbit when administered by the intravenous or intramuscular route. They furthermore show that antisera produced in this way possess a degree of specificity—a specificity not apparent in complement-fixation tests, but quite evident in bio-assays based on the effects of antisera on tumour growth.

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Longevity in Mice with a genetically determined Muscular Dystrophy

THE recent communications by Dowben[1] and Tubis *et al.*[2] regarding possible therapeutic procedures for mice with a genetically determined form of myopathy[3] have prompted this preliminary communication commenting on some problems relating to longevity in animals with this defect.

The value of such therapeutic work is three-fold. First, by prolonging the life-span of these animals it becomes possible to obtain critical details on the mechanism of the disease as it progresses. Secondly, effective therapeutic agents may give valuable leads regarding the primary metabolic nature of the defect. Thirdly, agents which prolong the life of animals with muscular dystrophy or alleviate the disease process would seem to be logical agents to employ in a clinical testing programme involving human beings with muscular dystrophy.

The last point is important because at present the rationale for employing certain therapeutic measures in patients suffering from various forms of muscular dystrophy is based largely on the results of tests in which experimental animals have been used[4]. If the results of these tests are accepted uncritically or their limitations not fully realized, it is likely that large amounts of time and money will be expended on clinical trials which unfortunately do not have the slightest probability of success.

Approximately two years ago we designed and initiated an experiment to test the efficacy of several agents in extending the life-span, and arresting the disease process, in mice suffering from a genetically determined muscular dystrophy. The agents used were felt to have potential value, by virtue of previous work either in our laboratories or in those of other investigators. It was our impression that in some reported work not enough attention had been paid to simple problems of animal management that might significantly influence the outcome of the experiments. Therefore, the method of handling the control animals in our experiment was determined by two observations made in routine mouse-colony maintenance. First, the transition period (between 2 and 2½ weeks of age), during which a suckling mouse changes to a diet of solid food, can be facilitated by the temporary use of a powdered form of the food pellet regularly used in the colony. Secondly, mice with muscular dystrophy often experience considerable difficulty in managing pelleted food and water when they are presented in the usual way through small glass tubes attached to inverted bottles. Regardless of whether these difficulties result from a generalized muscular weakness or from a particular involvement of the muscles of mastication, it was apparent that we had to entertain the hypothesis that these animals succumb to inanition resulting from their inability to consume sufficient pelleted feed or to a self-imposed inanition arising from an inadequate intake of water. It was decided, therefore, to maintain each of the animals in separate pens supplying them each day with fresh powdered food (U.B.C. mouse ration No. 6) and fresh water in small open vessels placed directly on the floor of the pen. The therapeutic substances being tested were added in appropriate levels to the powdered food.

While a number of the mice in various 'treatment' groups have lived for periods exceeding nine months, several of the untreated dystrophic animals in the control series have lived equally as long. One animal in the control group died at the age of eleven months and another still alive promises to exceed this record. So far as we are aware these are the oldest dystrophic mice yet reported.

Although the experiment is not yet complete, we believe that the results so far are significant in two principal respects: First, any claims regarding the ability of a particular agent to prolong the life-span of mice suffering from this form of muscular dystrophy must be examined with extreme caution and viewed against the background of adequately nourished control dystrophic survivors. Secondly, the progressive pathological changes previously described in this disease in the house-mouse should be re-examined in order to differentiate between those attributable to concomitant dietary deficiencies and those truly resulting from primary muscle disease.

Three additional points should be emphasized: First, not all the animals in this experiment have lived to the ages mentioned above. Secondly, there is no evidence that the disease process of the muscle is modified in any way since the affected animals still die prematurely and post-mortem examination demonstrates that muscle wasting is still extreme. Thirdly, our management procedure is begun some time after the first signs of the disease are observed[4].

On the basis of these three points we do not believe that the 'therapy' used in our experiments has any effect on the fundamental metabolic error underlying the disease, and we must stress emphatically that we are making no claims whatever about the life-prolonging ability of our diet. It seems more reasonable to believe that this ability, and perhaps that of the diet reported by Coleman[5], results from the provision of more of the essential nutrients per unit mass of feed and hence assures what is essentially an adequate intake of protein, energy and micro-nutrients.

A full report on this experiment together with pathological findings arising from it will be presented at a later date.

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Agglutination of Sensitized Alligator Erythrocytes by Rheumatoid Factor(s)

RECENTLY, it was found that alligator erythrocytes can be effectively used as carriers for reactant globulin in tests for rheumatoid factor(s)[1-3]. The cells are remarkable because most human sera do not contain heterophile antibodies to them, and the cells show extraordinary durability under osmotic and mechanical stress[1,2].

The present investigation was carried out to determine the effects of euglobulins from healthy individuals

and from patients with rheumatoid arthritis and other diseases, in agglutination of sensitized alligator erythrocytes by rheumatoid factor(s). Globulin fractions of ovalbumin (rabbit) antiserum were also tested.

Serum euglobulin fraction[4] or other inhibitors to be tested, in 0·2-ml. serial dilutions, were mixed with 0·2 ml. volumes of positive 2 plus agglutinating serum of a patient with rheumatoid arthritis, in 10 × 75 mm. test-tubes. The mixtures were incubated at 37° C. for 30 min. before testing with sediments of 0·1 ml. of 2 per cent saline suspension of sensitized alligator cells. The agglutination of sensitized alligator erythrocytes by rheumatoid arthritis serum was not readily inhibited by the euglobulin fractions of normal sera, unless the sera were native (not inactivated at 56° C. for 30 min.) and only if sera were diluted no more than 1 : 4. In contrast, euglobulins of subjects with rheumatoid arthritis gave even stronger agglutination than the control, suggestive of an enhancement, or summation effect. Results of a typical experiment are shown in Table 1. Some degree of depression of agglutination occurred with serum euglobulins tested of 3 patients with gout, 1 with lupus erythematosus, 1 with osteoarthritis, and 1 with rheumatoid spondylitis. No inhibition or depression of agglutination was observed with the euglobulins tested of 11 rheumatoid arthritis patients. Random readings of coded dilution tubes have indicated that one can reliably distinguish macroscopically between 2 plus and 1 plus degrees of agglutination of alligator cells. The nature of the depression, or summation of agglutination of sensitized alligator erythrocytes by euglobulin fractions, is under study. Well-defined inhibition of sensitized sheep cells and coated latex particles by euglobulins of sera of normal subjects has been reported by other authors[4–7]. The degree of inhibition of sensitized alligator cells was not so remarkable as reported by workers with red cells of other species or with latex particles.

Table 1. EUGLOBULIN INHIBITION OF ALLIGATOR ERYTHROCYTE AGGLUTINATION

Subjects	Sensitized alligator erythrocyte sediment								
	Dilutions of patient euglobulin								Saline control
	1:2	1:4	1:8	1:16	1:32	1:64	1:128	1:256	
	Fixed amount of positive-reacting rheumatoid arthritis serum								
Normal (*D*)	0	0	1	1	1	1	1	1	1
Normal (*C*)	0	1	1	1	1	1	1	1	1
Rheumatoid arthritis (*T*)	2	2	2	2	2	1	1	1	1
Rheumatoid arthritis (*S*)	2	2	2	2	2	1	1	1	1

Agglutination of sensitized alligator cells by 1 volume of rheumatoid arthritis serum was readily inhibited by addition of 1 vol. of 5 per cent human, rabbit, or bovine γ-globulins. However, 5 per cent bovine albumin ('Ortho') or human albumin ('Cutter') added to the saline buffer diluent enhanced the degree of agglutination. The mechanism of the enhancement is being investigated.

Inhibition of the agglutination of sensitized alligator erythrocytes was observed by γ-globulins obtained from ovalbumin rabbit antiserum and by γ-globulin fragments, prepared by Porter's method[8]. Chromatographic fractions (Porter fractions I, II and III) of the rabbit antibody γ-globulins were also tested. Fraction III, at 1·75 mgm./ml., inhibited rheumatoid factor agglutination of sensitized alligator cells. Fraction I, which is reactive with the ovalbumin antigen, did not inhibit rheumatoid factor agglutination at a maximal concentration tested of 4·15 mgm./ml.; neither did fraction II, which is also reactive with ovalbumin antigen, at a concentration of 1·90 mgm./ml. Limited amounts of the globulin fragments were available. Ultracentrifugal examination showed no visible contamination by undegraded whole globulin. The observations indicate that not all globulin fragments are active or equally active as inhibitors of rheumatoid factor haemagglutination and suggest that there are one or more specific combining sites on the rabbit globulin which interact with the rheumatoid factor(s). In the light of the recent report of Edelman *et al.*[9] of antigenic specificity of 2 human γ-globulin fragments (*F* and *S*) obtained after papain treatment, it might be important to investigate their capacity to combine with rheumatoid factors. The physico-chemical characteristics of globulin fragments which determine inhibitory or lack of inhibitory capacity require further study.

Alligator erythrocytes are found to lend themselves to detection of rheumatoid factor(s) by direct or inhibition haemagglutination procedures.

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BIOLOGY

Effect of *Isonicotinyl* Hydrazide on the Path of Carbon in Photosynthesis

In a study of the pathways of incorporation of carbon-14 from labelled carbon dioxide into the amino-acids glycine and serine during photosynthesis the compound *iso*nicotinyl hydrazide (isoniazid) was used. This compound has been shown to be an inhibitor of transaminases *in vitro* when used at high concentrations (about 10^{-2} *M*)[1,2].

Cells of *Chlorella pyrenoidosa* (Emerson strain) were grown for four days at 25° C. in illuminated culture tanks. 1,200 μl. wet packed volume of cells were suspended in 105 ml. of 10^{-4} *M* potassium dihydrogen phosphate at *p*H 4·5 and the suspension

divided into three samples. Isoniazid was added to two of the samples to give concentrations of 10^{-2} *M* and 10^{-3} *M*. The third sample was used as a control. The samples were aerated in the dark for 1 hr. and were then illuminated (light intensity approximately 10,000 lux). Air containing 0·1 per cent carbon dioxide was passed through the suspensions. After 15 min. photosynthesis, 30 μc. of sodium carbonate-^{14}C were added to the suspensions. After a further 10 min. photosynthesis the cells were killed by boiling ethanol. The distribution of carbon-14 among the ethanol-soluble compounds was examined by the procedures of Benson *et al.*[3].

The total fixation of carbon-14 and the distribution of carbon-14 between the ethanol-soluble and ethanol-insoluble fractions is shown in Table 1.

Table 1. CARBON-14 FIXED BY *Chlorella* DURING PHOTOSYNTHESIS (EXPRESSED AS COUNTS PER MIN. PER ML. OF CELLS × 10^{-3}). THE LIMITS OF VARIATION ARE ABOUT ± 5 PER CENT)

	Control	Isoniazid (10^{-3} *M*)	Isoniazid (10^{-2} *M*)
Total fixation	5,340	5,960	5,630
Ethanol soluble fraction	2,978	3,530	3,460
Ethanol insoluble fraction	2,395	2,339	2,157

Isoniazid had only a small effect on the total fixation of carbon-14 and on the distribution between the ethanol-soluble and ethanol-insoluble fractions. There is a slight stimulation of total uptake and carbon-14 content of the ethanol-soluble fraction which is probably significant.

The effect of isoniazid on the distribution of carbon-14 among the compounds of the ethanol-soluble fraction is shown in the histogram of Fig. 1.

The incorporation of carbon-14 into sugar phosphates, phosphoglyceric acid, phosphoenol pyruvic acid, aspartic acid, malic acid, fumaric acid and alanine is considerably reduced by treatment with isoniazid. Incorporation into sucrose is stimulated at the lower concentration and slightly inhibited at the higher concentration. Incorporation into the two-carbon compounds, glycollic acid and glycine, is stimulated about 5- to 8-fold by treatment with 10^{-2} *M* isoniazid and these two compounds account for more than 80 per cent of the total ethanol-soluble

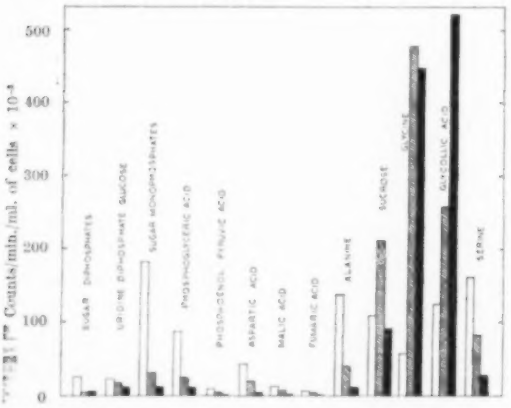

Fig. 1. The effects of treatment of *Chlorella pyrenoidosa* with *iso*nicotinyl hydrazide on the incorporation of carbon-14 into ethanol-soluble compounds during photosynthesis in $^{14}CO_2$. Counts were made directly on paper chromatograms and have not been corrected for self-absorption. White, control; hatched, 10^{-3} *M* isoniazid; black, 10^{-2} *M* isoniazid

carbon-14. Incorporation into serine, which previous evidence suggests is derived from glycine during photosynthesis[4], is inhibited to the same extent as that into sugar phosphates, phosphoglyceric acid, etc. It has been shown by Dac and Wriston[5] that isoniazid inhibits the condensation of formaldehyde and glycine during the formation of serine from sarcosine. Therefore the above results are not necessarily incompatible with the view that serine is derived from glycine during photosynthesis.

Thus in its effect on the photosynthetic carbon cycle, isoniazid differs from azaserine. The latter substance has been shown to inhibit the transaminases fairly specifically and does not inhibit incorporation of carbon-14 into sugar phosphates and phosphoglyceric acid[6]. The effects of isoniazid on *Chlorella* are similar to those obtained by treatment of *Scenedesmus* with low concentrations of ethanol[7]. Incorporation of carbon-14 into phosphoglyceric acid and sugar phosphates during photosynthesis was inhibited by ethanol treatment while incorporation into glycollic acid and glycine was unaffected or even enhanced. Ethanol, however, inhibited total fixation of carbon-14 quite markedly while in our experiments isoniazid did not. The above results do not indicate specific inhibition of transaminases by isoniazid but suggest a different site of action.

This work is part of a research programme primarily concerned with carbon metabolism in photosynthetic organisms sponsored by the Office of Scientific Research of the Air Research and Development Command, U.S. Air Force through its European Office, under Contract No. *AF* 61(052)-245. The implications of these results will be discussed in a fuller account of this work to be published elsewhere.

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Taxonomic Significance of Surface Lipids of Plants

WHILE investigating the composition of surface lipids of plants, we have observed that the chemical composition of the lipid appears to be characteristic of the species of plant. The lipids were extracted from leaves by immersing them for 10 sec. in ether. According to Martin *et al.*[1], and in harmony with our own findings, this treatment does not extract lipids from within the leaf. After removal of the solvent, the residues were chromatographed on thin films of silica supported on glass plates. Three solvents were used for the elution: benzene, benzene containing 5 per cent methanol, and benzene containing 10 per cent methanol. The positions of the components were revealed by spraying separate plates with two reagents: chloroform saturated with

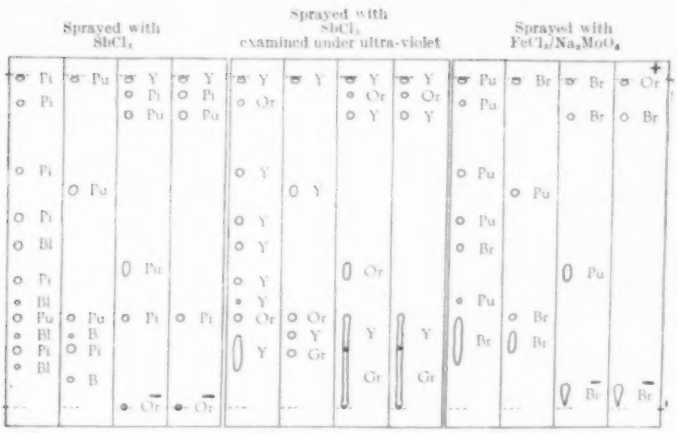

Fig. 1. Drawing of two plates eluted with benzene containing 10 per cent methanol. *R*, *Rhododendron ponticum*; *I*, *Ilex aquifolium*; *O*, *Festuca ovina*; *G*, *Festuca rubra genuina S59*: *Bl*, black; *Bl*, blue; *Br*, brown; *Gr*, green; *Or*, orange; *Pi*, pink; *Pu*, purple; *Y*, yellow; +, intense; −, pale

antimony trichloride, and saturated aqueous ferric chloride followed immediately by 0·1 molar sodium molybdate. Both series of plates were heated to 200° C. for 10 min. for full development of the colour. If the plates which were to be sprayed with antimony trichloride were first heated to 200° C. for 10 min. and sprayed while hot, the components showed a large range of colours. Subsequent examination in ultra-violet light showed a less-extensive range of fluorescent colours. Specimen chromatograms in one solvent are shown in Fig. 1.

Although the relative positions occupied by the components are always the same, their R_F values are sufficiently variable to render them of little use in comparing one chromatogram with another. For simplicity, we shall refer to the complete data from six separate chromatograms for each lipid, having regard to the colours of the spots obtained with each spray reagent, and their relative positions when eluted with different solvents, as its pattern. Characteristic patterns were given by each of the surface lipids from 10 species of monocotyledons (*Festuca elatior pratensis S56*; *F. ovina*; *F. rubra genuina S59*; *Dactylis glomerata S143* and *S26*; *Phleum pratense S50* and *S51*; *Agrostis tenuis*; *Alopecurus pratensis*; *Lolium italicum*; *L. perenne*; *Holcus mollis*) and 14 species of dicotyledons (*Rhododendron ponticum*; *Ilex aquifolium*; *Fraxinus excelsior*; *Aesculus hippocastanum*; *Malus* spp. edible form; *Rosa* hybrid *H.T.* garden variety; *Brassica oleracea* sub-sp. *gemmifera*; *B. oleracea capitata*, red and winningstadt; *Chrysanthemum* garden variety; *Antirrhinum majus* cultivated; *Petunia* spp.; *Beta vulgaris* (sugar beet type *E*); *Trifolium repens S100*).

Before the taxonomic value of the patterns could be considered seriously, three further variables had to be examined: first, it must be established that foliage from different parts of the plant gives the same pattern. For brussels sprout this is certainly true. Lipids from the main leaves and from the outer and inner leaves of the bud all had the same pattern, although the relative concentrations of the components were different, and so too were the weights of lipid per unit area on the inner and outer leaves of the bud.

Secondly, we found that the lipids on the leaf are relatively stable; precisely the same patterns were obtained from freshly cut leaves as from leaves which had been stored for thirteen days. However, once the lipids had been extracted from the leaf, auto-oxidation was detectable by a change in the pattern after the same period.

Thirdly, it was established that the pattern did not change as the plant aged. Waxes from leaves of various ages from *Rhododendron ponticum* and from *Ilex aquifolium* had patterns that were independent of age. Two groups of the 12 grasses were examined; one group had been grown from seed one year before the second group. Once again the patterns were independent of time.

Bate-Smith *et al.*[2] have suggested that the occurrence of tannins in plants may be a useful taxonomic character. Our observations show that a brief qualitative analysis of the surface lipids of plants provides more useful data, even if the identities of the components have not been established.

The technique may be capable of extension to Arthropoda.

We are indebted to Prof. J. B. Speakman, to Miss D. M. Turner for advice and supplies of material, and to the Agricultural Research Council for financial assistance.

Note added in proof. The observations have now been extended to a total of 63 species.

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Botryodiplodia theobromae Pat. and *Nigrospora* sp. in the Air of a Jamaican Banana Plantation

Cammack[1] has commented on the lack of detailed information about the composition of the air spora in tropical climates. On the other hand, Hirst[2,3] and others have contributed much to our knowledge of fluctuations in the air spora in a temperate climate. Seasonal changes in three common constituents (*Puccinia polysora*, *Nigrospora sphaerica*, *Cladosporium* spp.) of the air spora of Southern Nigeria have been described by Cammack[1]. The observations described here were made during an investigation[4-6] chiefly designed to provide information about dispersal of *Deightoniella torulosa*, the cause of fruit-spot ('speckle') of Jamaican bananas.

Botryodiplodia theobromae Pat. is a widespread saprophyte and wound-parasite on a considerable range of hosts in the tropics. It is an important parasite of bananas in storage, causing several forms of fruit-rot[7,8]. The pycnospores are elliptical, at first unicellular and hyaline, becoming brown and 1-septate, sometimes with longitudinal striations: dimensions are 20–30 × 10–18μ. There is little risk

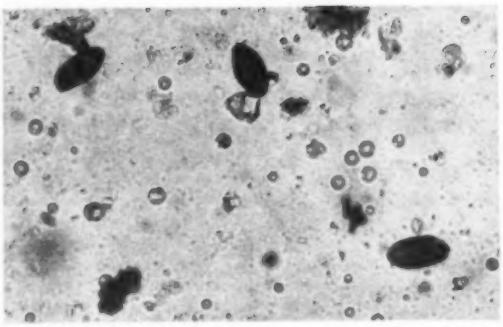

Fig. 1. Relatively large dark-coloured pycnospores of *Botryodiplodia theobromae* from air sampled in a Jamaican banana plantation. (× *c.* 300)

of confusing these spores with those of any other species (Fig. 1). The fungus produces pycnidia on dead or dying banana leaf 'trash', bracts and decaying fruit in the plantation.

A species of *Nigrospora* variously named *N. sphaerica* (Sacc.) Mason[9] or *N. musae* McLennan and Hoette[10] is responsible for the serious 'squirter' disease of banana fruits in Queensland. It is a common saprophyte on banana debris inside the plantation. *N. oryzae* (Berk. and Br.) Petch is also saprophytic on decaying banana tissue. These fungi may be synonymous, and, until further work has been carried out in Jamaica, it is proposed to refer to the fungus discussed here as *Nigrospora* sp. The conidia, which are borne terminally on simple conidiophores, are sub-globose or globose, black and measuring 15 × 18μ or 13–18μ in diameter (Fig. 2).

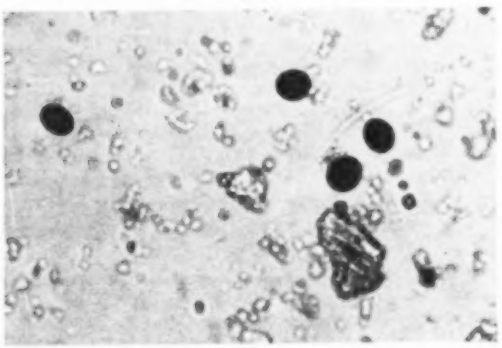

Fig. 2. Sub-globose or globose, black conidia of *Nigrospora* sp. trapped in a banana plantation. (× *c.* 300)

A Hirst spore trap (automatic volumetric) was set up inside a plantation of Lacatan bananas situated on the plains of St. Catherine, Jamaica. The trap orifice was three metres above ground-level. Slides were prepared and mounted in the manner described by Hirst[3], and were changed daily at 09.00 hr. E.S.T. On each slide, traverses 40μ wide and at right angles to the direction of slide movement were scanned at positions representing 2-hourly intervals. The number of spores counted on each cross-traverse was then converted into an estimated number per cubic metre of air. Since no corrections for variation in trapping efficiency were made, all concentrations recorded were under-estimates of the true ones.

The diurnal periodicity curve for *Nigrospora* sp. (Fig. 3) was derived from the geometric means for spore concentration at each even hour, plotted according to Hirst[3]. Also shown are the 2-hourly means for temperature and relative humidity. Each mean was based on counts over sixty-three days (July 19–September 20). The fungus exhibited a well-defined periodicity with peak concentrations occurring near 08.00 hr. each day. After this there was a progressive decrease to a characteristically low night level. This periodicity is similar to that for *D. torulosa*[4], *N. sphaerica*[4], *Phytophthora infestans*[3] and *Polythrincium trifolii*[3,11]. Hirst[3] has suggested that such regularity may be due to the operation of a definite discharge mechanism or to the occurrence each day of environmental conditions favouring spore liberation. Violent spore liberation in *D. torulosa* occurs under conditions of rapidly decreasing vapour pressure[3], usually between 08.00 hr. and 10.00 hr. Webster[12] has described active discharge accompanying drying in *N. sphaerica*, thus helping to explain the periodicity of the fungus in Nigeria. The possibility that a similar process occurs in *Nigrospora* sp. is being investigated.

Variation in absolute numbers of spores of *Nigrospora* sp. appears to be related to rainfall and humidity; highest counts were obtained during predominantly dry weather. The highest 2-hourly estimate recorded so far is 20,000 spores per cubic metre of air at 08.00 hr. There is considerable variation in spore

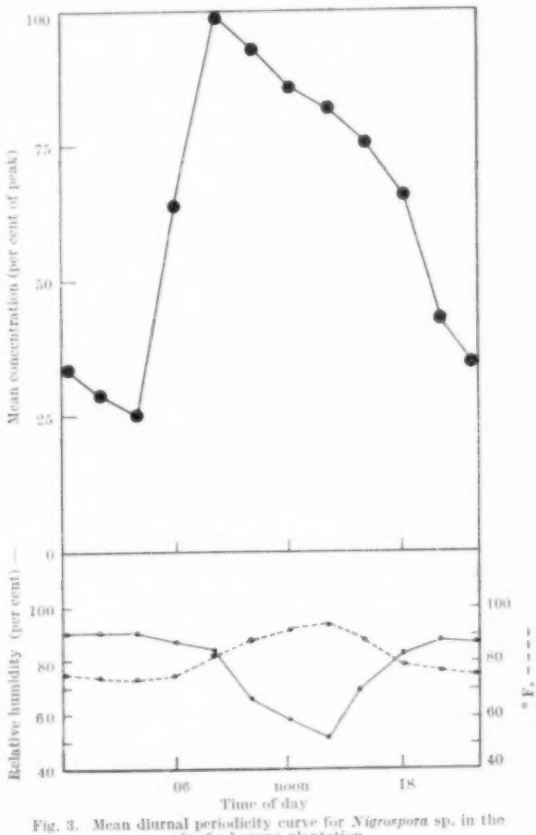

Fig. 3. Mean diurnal periodicity curve for *Nigrospora* sp. in the air of a banana plantation

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content between different plantations. Although this will be discussed more fully elsewhere, it seems clear that *Nigrospora* sp. is an extremely common component of the air spora of Jamaican banana plantations.

Because of the small numbers of *B. theobromae* spores trapped, it was not possible to distinguish any clearly defined periodicity. It was, however, unusual to trap spores during the period 20.00–06.00 hr. The highest 2-hourly estimate recorded was 858 spores per cubic metre, when a clump of spores was trapped. The average daily mean concentration throughout the sampling period was only 8 spores per cubic metre. Such meagre counts could not be correlated with fluctuations in weather conditions. It was concluded that this fungus is a relatively infrequent member of the plantation air spora.

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Biotin Requirement and Carbon and Sulphur Sources in *Aspergillus* and *Neurospora*

CONIDIA of the mould *Aspergillus nidulans* were unexpectedly found to require a small amount of biotin (or larger amounts of desthiobiotin) for initial growth, when plated on to a minimal medium of Czapek–Dox, at a density of no more than 10^3 per dish. This fact seems to be in contradiction to what was previously considered to be their basic requirement. Biotin must be added to the minimal medium, for a total germination of wild-type conidia, to the extent of 10^{-6} gm./ml. This corresponds to about 1/100–1/10 of the amount required by the biotinless mutant *bi*-1.

Sometimes a few wild type conidia germinate in the absence of biotin to give rise to normal colonies, the conidia of which, however, have not acquired biotin independence.

When the carbon source (usually glucose 4 per cent) is replaced with an equal concentration (w/v) of fructose, ribose, glycerol or intermediates of the Embden–Meyerhof, of tricarboxylic, or pentose cycle (pyruvate, acetate, succinate, citrate, gluconate) good growth takes place in the absence of biotin. If the glucose is replaced with an equal concentration of sucrose, maltose or dextrin, the basic requirement for biotin is retained. Under our conditions glucose-6-phosphate or glucose-1-phosphate are not utilized as carbon sources (even with added biotin).

Mixtures of glucose and fructose support growth in the absence of biotin, if the amount of fructose is equal or superior to the amount of glucose, whatever the total sugar concentration in a large range (0·2–8 per cent).

A role of biotin in glycolysis, namely as a coenzyme in the hexokinase or in glucose-6-phosphate dehydrogenase systems, was proposed by Moat and Liechstein and Strauss and Moat[2] in biochemical work with *Saccharomyces*. However, this finding was not confirmed by Siepmann and MacDonald[3]. Our results with the carbon sources are compatible with a role of biotin in some initial steps of glucose metabolism.

A variety of nutritional mutants (*ribo*-1, *an*-1, *pro*-1, *paba*-1, *ad*-20, *nic*-2, *lys*-5, *orn*-4) retained the basic biotin requirement of the wild-type, except the parathiotrophic mutant *s*-12, which grew, although with a delay of 24–48 hr., in the absence of biotin. (For description of mutants see Käfer[4].) As this mutant requires reduced sulphur as the only addition in a minimal medium, we looked for a possible effect of the replacement of the source of sulphur on the biotin requirement.

Replacement of 4 m*M* sulphate (which is the only source of sulphur in the Czapek–Dox minimal medium) by an equimolecular concentration of reduced sulphur (sulphite, thiosulphate, sulphide, cystein) or cysteic acid, allows wild-type conidia to give rise to colonies in the absence of biotin, though growth is delayed 24–48 hr. Addition of biotin ($2·5 \times 10^{-9}$ m*M*) restores the growth to a normal rate.

Methionine, which is utilized in the presence of biotin as a reduced sulphur source by the parathiotrophic mutant, does not support growth in the absence of biotin. Moreover, the methionineless mutant *meth*-1 retains the biotin requirement of the wild-type.

A wild-type strain of *Neurospora crassa*, commonly regarded as a biotin-requiring mould, is able to grow in the absence of biotin if glucose is replaced by fructose, or sulphate by sulphide, on the same Czapek–Dox minimal medium. In the latter case, growth is improved by the addition of biotin.

Many species of moulds are reported to need biotin[5]. It would be of interest to elucidate the mechanism of this requirement, which appears to be similar in *Aspergillus* and *Neurospora*.

This work was aided by a grant to one of us (P. S.) from the Comitato Nazionale per l'Energia Nucleare.

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Transfer of Ova to the Bursa Ovarii and the 'Suspended Loop' of Tube in the Rabbit

IN mammalian species successful ova transfer is possible when the ova are replaced inside the Fallopian tubes or uteri of laparotomized synchronous recipients. In species with confined bursa ovarii, like the mouse, the ova can be transferred into the fat pad adjacent to the bursa ovarii, through the capsular membrane and into the bursa proper[1]. Intravaginal ova transfer was not successful in cattle[2], owing

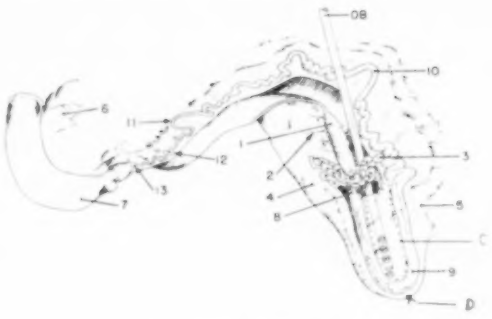

Fig. 1. Diagram of experimental treatments: removal of membrane of bursa ovarii (*C*), induced adhesions in suspended loop (*D*) and ova transfer to ovarian bursa (*OB*). 1, ovary; 2, ovarian artery and vein; 3, appendix vesiculosa; 4, mesosalpinx; 5, suspended mesosalpinx; 6, broad ligament; 7, uterus; 8, infundibulum; 9, suspended loop (ampulla); 10, embedded ampulla; 11, major loops (isthmus); 12, minor loops (isthmus); 13, utero-tubal junction (intramural sphincter)

to increased sensitivity to bacterial infection and pyometra during the luteal phase[3]. A few cases of intravaginal ova transfer in the rabbit were successful when antibiotics were used[4]. Intraperitoneal insemination has been successful in several species such as the rabbit[5], guinea pig[6,7], cattle[8], pigeon and hen[9]. Intraperitoneal ova transfer has not been possible yet.

The tubo-ovarian anatomical relationships are of some importance for the reception of ova. The ampulla of the tube is not held in position, but it forms a loop *suspended* in the pelvic cavity (Fig. 1). This loop is attached to a thin fold of the peritoneum which is connected to the mesosalpinx. This thin fold, together with the fatty pad attached to the suspended loop, makes the ovarian bursa. The transit of the ovum from the ruptured follicle to the utero-tubal junction is ensured by two series of complex processes; mechanisms for 'reception' or 'adjustment' and mechanisms for tubal 'transportation'.

This work was undertaken to evaluate the physiological significance of suspended loop in ova reception and the possibility of transfer of ova in the ovarian bursa of the rabbit.

Exp. 1: Seven adult does were laparotomized on both sides and the Fallopian tubes exposed. On one side, the membrane attached to the suspended loop of the ampulla (which is part of the ovarian bursa) was removed by fine scissors (Fig. 1). The does were allowed 3 days to recover from the operation, then mated (with or without superovulation) to fertile bucks and killed 40, 50 and 98 hr. *post coitum*. The ampulla, isthmus and uterus were dissected and flushed separately with saline. The ova were examined microscopically. The diameter of blastocysts was measured.

Exp. 2: Twenty donors were superovulated, mated to fertile bucks, killed 16–40 hr. *post coitum*, and the ova were flushed out. The healthy ova were transferred to twenty synchronous pseudo-pregnant recipients. In one side of the recipient, the ova were transferred to the bursa ovarii (Fig. 1). In the other side, the ova were transferred at different parts of the tube. The recipients were either killed 2, 3 or 4 days *post coitum*, or laparotomized 8 days *post coitum*. When killed, the reproductive tract was dissected and the ampulla, isthmus and uterus flushed separately. The flushings of each portion were examined microscopically. Pregnant recipients were allowed to proceed to term.

Exp. 1: When the membrane of the bursa ovarii was removed, the reception and transportation of the ova in the tube were not affected. The number of ova recovered corresponded to the number of ovulation points, that is, there was no loss of ova. In two cases, however, 11 and 33 per cent of the ova shed were not recovered in the flushings. This could not be ascribed only to faults of flushing or manipulation. It may have been due to the loss of ova in the peritoneal cavity through the fimbriated end of the tube or to the absence of ova in the follicles.

When the suspended loop was attached to the mesosalpinx, the transportation of ova from the ampulla to the uterus was normal. Ova reception was affected and ova loss increased, ranging from 13 to 33 per cent of ova shed. This may be due to the adhesions which were induced by the experimental treatment. It is possible that the pendulous structure of the suspended loop helps in the reception of the ova.

There were no significant differences between the size of blastocysts in the two experimental treatments. There were wide individual variations in the intrazonal diameters and outside diameters of blastocysts. This may be partly due to differences in the cleavage-rate of fertilized ova in the same animal.

Exp. 2: When 1-cell fertilized ova were transferred to the ovarian bursa, ova pick-up by the fimbria occurred in 57 per cent of the cases. The percentage of transferred ova picked up varied from 0 to 35, with an average of 10. The rate of passage of the alien ova was similar to that of the recipient's own native unfertilized ova. This may indicate that the ova were picked up from the ovarian bursa in a relatively short time. The ova which were transferred to the ovarian bursa had normal subsequent development and implantation. The young delivered were also normal.

When 8–16-cell ova were transferred into the ovarian bursa of synchronous recipients, ova pick-up was recorded in 88 per cent of the cases. The percentage of transferred ova which were picked up varied from 0 to 25 with an average of 12. When the 1-cell or 8–16-cell ova were transferred to different parts of the tube, the percentage ova pick-up ranged from 41 to 44 with an average of 42. Ova were not picked up when transferred to the peritoneal cavity very close to the fimbria in 1-day pseudo-pregnant recipients (Hafez, unpublished work).

The present work and other comparative investigations have elucidated, to a certain degree, the physiological importance of the tubo-ovarian anatomic arrangement. The physiological significance of the suspended loop of the tube is not exactly known. It may be the agency by which the ovum is transported rapidly in this portion of the tube, as compared with the rate of ovum transport of the isthmus. The relative physiological significance of such anatomical structure in other species is also of academic significance.

Apparently, the membrane attached to the suspended loop which makes the ovarian bursa was of little importance in reception of ova. Adhesions induced in the suspended loop increased the percentage of ova lost in the peritoneal cavity. The fimbria was able to pick up 1-cell or 8–16-cell ova if transferred to the bursa ovarii of synchronous recipients. The percentage pickup was lower than when ova were transferred to the tube. Detailed results of this work will appear elsewhere.

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Seal Tracks in the Taylor Dry Valley

The mummified carcasses of the crab-eater seal (*Lobodon carcinophagus*) are found in many places in the ice-free regions around McMurdo Sound in the Ross Dependency, Antarctica[1]. All these carcasses appear to be old. Some have only fragments of tissue on the bones, but others, although desiccated and wind blasted, are well preserved. One carcass has been dated[1] giving an age of 1,600–2,600 yr.

During a soil survey in the summer of 1959 of the Taylor Dry Valley I observed many carcasses, probably including a number of those observed by Scott[2], Griffith Taylor[3] and Péwé's party[1]. Most of these carcasses also appeared to be old, wind blasted and in some cases only scattered bones were observed. Three carcasses were observed on the ice of Lake Bonney at the western end of the Dry Valley although more were observed on the ice of other lakes in the Valley. It is difficult to estimate the age of the carcasses, because of the very low rate of organic decomposition in the arid, cold climate of the valley, but casual observation leads to the conclusion that most of the carcasses are of similar age—probably as old as the carcass the age of which was determined by Péwé *et al.*[1]. However, on a small alluvial plain at the eastern end of a large lake in the Taylor Valley, the track of a seal was observed. This was a furrow in the sand, about 1 in. deep and 6 in. wide, following an irregular course across the plain. It showed flipper marks and places where the seal had rested, and changed direction. Similar tracks were observed on beaches at Cape Evans and Cape Royds. The track disappeared under snow-drifts at either end, so that it must have been made before the winter of 1959. The Valley has been visited many times in the past few years, and footprints, helicopter wheel impressions and other traces of human activity are quite common, including some that must have been made during the autumn of 1956, when a meteorological station in the Valley was occupied. This means that such minor impressions are not removed rapidly by climatic influences and persist for at least 5 yr. Judging by the state of preservation of the track and comparing it with footprints in the neighbourhood, the track appears to be less than 5 yr. old. A search was made for the seal, but it was not found. A lake was not far distant, and the seal could have reached it and entered the water at the thaw-moat that appears during the summer.

The site where the tracks were observed lies about 6 miles from the coast, and the intervening country is covered with ridges of moraine several hundred feet high. During the summer period the ground was bare except for occasional small patches of snow.

No seals have been observed in the act of crawling inland. If all the carcasses are of similar age, as they appear to be, then the conditions that cause seals to move inland may have existed at some time about 2,000 yr. ago and the presence of seals on any land surface must mean that the surface is older than about 2,000 yr. However, if the track observed indicates that seals do still travel inland occasionally, then the age of each carcass must be measured to determine a minimum age for the land-form. Observations in the Taylor Valley seem to indicate a rather complicated history of ice-movements. Some figures on the age of land-forms may help to sort out this history.

If the twenty or so carcasses observed in the Taylor Valley represent all the seals that have travelled up the Valley in the past 2,000 yr. and that there has been the same tendency to wander inland during this period, then the rate is approximately one every hundred years. Even if more carcasses are present, but not observed, and if others have crawled into moats at the edges of frozen lakes, then the rate is still very low. The carcass dated by Péwé *et al.* may not be the oldest in the Valley and the rate would then be still slower. It is possible that carcasses of seals dehydrate rapidly in the arid climate and after a short period reach a stage of decay which does not proceed further, and thus all observed carcasses appear of similar age.

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ENTOMOLOGY

Resistance to Dieldrin in *Anopheles* in Trinidad

Dieldrin has been in use as a larvicide against *Anopheles neomaculipalpus* Curry for several years in the Piarco Airport area of Trinidad. This species is of secondary importance to *Anopheles aquasalis* as a vector of malaria in the coastal areas of the Colony.

Lack of proper control recently in the Piarco area raised suspicions that the species was showing some degree of resistance to dieldrin. Susceptibility tests with the standard World Health Organization mosquito adult test kit using freshly blooded wild-caught specimens taken from calf-baited Shannon dawn traps gave the results with DDT and dieldrin shown in Table 1.

It is to be noted that about 27 per cent of the mosquitoes tested survived 1·6 per cent dieldrin papers for 8 hr. and there was a 5 per cent survival

Table 1. *Anopheles aquasalis* Curry. Locality: Piarco Airport Area, Trinidad

Date of test 1960	No. of tubes	Concentration (per cent)	Exposure time (hr.)	No. of mosquitoes tested	Dead (per cent)	Control	
						No. tested	Dead (per cent)
			DDT Preliminary, 1960				
July 26	1	DDT, 0·25	1 hr.	23	17·4	26	
July 26	1	DDT, 0·5	1 hr.	26	34·6	26	
July 27	1	DDT, 1·0	1 hr.	26	73·0	26	0
July 18	1	DDT, 2·0	1 hr.	24	87·5	26	
July 28	1	DDT, 4·0	1 hr.	26	100	26	
			DDT Replicates, 1960				
July 29	4	DDT, 0·5	1 hr.	102	25·5	24	0
August 3–4	4	DDT, 1·0	1 hr.	102	56·0	26	0
August 5–6	4	DDT, 2·0	1 hr.	101	90·0	26	0
August 8–9	4	DDT, 4·0	1 hr.	102	100	27	0
			Dieldrin, 1959				
September 5–12	7	Dieldrin, 1·6	1 hr.	98	58·2	28	0
December 14–17	5	Dieldrin, 4·0	1 hr.	90	84·9	26	0
			Dieldrin, 1960				
August 15–17	4	Dieldrin, 1·6	1 hr.	99	35·3	25	4
August 12–13	4	Dieldrin, 1·6	2 hr.	101	43·5	26	0
August 11–12	4	Dieldrin, 1·6	4 hr.	102	63·7	25	0
August 10	4	Dieldrin, 1·6	8 hr.	103	72·8	25	8
August 23–26	4	Dieldrin, 4·0	1 hr.	95	85·3	25	0
August 25–30	4	Dieldrin, 4·0	8 hr.	105	95·1	24	0

even after 8 hr. exposure to 4 per cent dieldrin papers, indicating that the species is clearly resistant to dieldrin.

The tests with DDT show that despite DDT residual house spraying for several years in the nearby villages for malaria control, the species is still susceptible to this insecticide. The LD_{50} as determined on logarithmic-probability graph paper is about 0·8 per cent DDT.

This is the second anopheline to show resistance to dieldrin in Trinidad, the other being *Anopheles aquasalis*, which was first shown to be resistant in 1958.

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A Differentiation Centre in the Embryo of *Dacus tryoni*

In several insects the cells of the embryonic blastoderm have been shown to depend for their further development on a stimulus emanating from a ventral prothoracic differentiation centre[1,2]. In cyclorrhaphous Diptera a similar centre has so far escaped detection, although Yao[3] has proposed one for *Drosophila melanogaster* on the basis that alkaline phosphatase activity is first detectable in the ventral prothoracic region during contraction of the germ band and spreads both anteriorly and posteriorly as histo-differentiation proceeds. Further results bearing on this question have now been obtained by the application of ligatures to the early embryos of *Dacus tryoni* (Diptera, Trypetidae (= Tephritidae)).

Methods for maintaining breeding stocks of *D. tryoni* in the laboratory are described by Bateman[4]. Development of the eggs, an account of which will be published in due course, follows the typical dipteran pattern, with cleavage leading to the formation of a blastoderm by 7½ hr. at 25° C. and subsequent gastrulation, elongation and shortening of the germ band, involution of the head and completion of histo-differentiation resulting in hatching at 42–48 hr.

In the present work nine batches of 20 eggs were used. In each batch 10 eggs were set aside as controls, and the remaining 10 identically ligatured at a known time after oviposition. Three batches were treated at 2–3 hr. (cleavage nuclei invading the cortex), three at 4½–5½ hr. (syncytial blastoderm) and three at 6–7 hr. (cellular blastoderm). For each the ligatures were so placed as to separate, in the first batch, the anterior third of the embryo from the posterior two-thirds, in the second, anterior and posterior halves and in the third, the anterior two-thirds from the posterior third. The eggs were then allowed to develop until the normal time of hatching and examined after removal of the chorion by immersion for 30 sec. in a commercial solution of sodium hypochlorite.

Control eggs developed normally. Of the ligatured eggs, approximately half of each batch was incompletely divided by the ligature, the two parts of the embryo being joined by a narrow neck. Development in these also proceeded normally. Where successful ligature completely separated the two parts, however, the following observations were made:

(*a*) Ligature at 2–3 hr. at the border of the anterior third resulted in normal development of the posterior two-thirds, but in cessation of development of the anterior third at the blastoderm stage. Ligature at or behind the equator at this time, conversely, allowed normal development of the anterior part, but caused cessation of development of the posterior part at the blastoderm stage.

(*b*) Ligature at 4½–5½ hr. either at the border of the anterior third or at the equator had no effect on the development of either part of the embryo, but ligature at the border of the posterior third again caused cessation of development of the posterior part at the blastoderm stage.

(*c*) Ligature at 6–7 hr. allowed both parts of the embryo to develop normally, irrespective of the position of the constriction.

It can be concluded, therefore, that a differentiation centre lying between the border of the anterior third and the equator of the egg begins to produce at 3 hr. after oviposition a stimulus, presumably chemical, essential to the further development of the blastoderm, and that the stimulus spreads both

forwards and backwards, reaching beyond the equator of the egg by 4½ hr. and into the posterior third by 6 hr. Descriptive studies confirm that the site of the differentiation centre is the prothoracic segment, as in other insects, and also reveal that subsequent major events in gastrulation begin at this point. Further investigations are now being pursued to localize the differentiation centre of *D. tryoni* more precisely.

The present work also confirms that determination in the cyclorrhaphan egg is completed at a very early stage[5,6], since none of the developing parts here separated by ligature showed regulation.

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Distribution of *Acarapis woodi* (Rennie)

Mites determined as *Acarapis woodi* (Rennie) were found recently on one of the escorts with a queen bee (*Apis mellifera* L.) from California. This suggested a wider distribution than previously recorded, and a survey of commercial apiaries in Queensland was commenced. The mite is widely spread on bees in this State.

In the meantime *A. woodi* was found on bees from other American States, New Zealand, and also from Italy.

These findings certainly extend the known distribution of the species.

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Numerical Regulation of Populations of the Codling Moth, *Cydia pomonella* (L.)

The numerical regulation of the codling moth has been investigated in the Australian Capital Territory. Each year, part of the population undergoes two complete generations and begins a third, most individuals of which fail to survive. The other part of the population enters diapause, and the species overwinters as mature, diapausing larvæ produced mainly in the second generation.

The level of infestation is always very high in unsprayed orchards, irrespective of size of crop. It was found that the pest multiplies each year to densities which are limited by the supply of larval food, that is, pome fruits, particularly apples.

The extreme suitability of the local environment for codling moth is determined by: (1) a very long season, extending from mid-October to late March, during which weather conditions are almost continuously favourable; (2) the extensive use of a very late maturing apple variety (Granny Smith); and (3) the absence of effective antagonists.

Intraspecific competition both for larval food and for cocoon shelter is the essential mechanism for

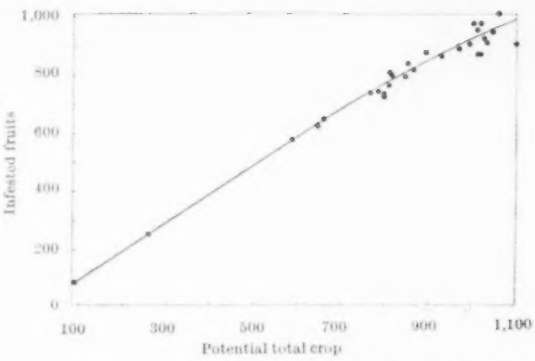

Fig. 1. Relationship between the potential number of fruits and the number of fruits penetrated by codling moth per tree. Dots, observed values; line, calculated values

numerical adjustment of the species in this environment.

It is known that larvæ may feed successively in several fruits, and that several larvæ may develop from the same fruit. However, these occurrences are exceptional. In general, only one individual survives after simultaneous infestation of the same fruit by several larvæ and one mature larva is produced for almost every infested fruit. Competition for larval food is thus a form of contest[1].

In a homogeneous plot of twenty-nine apple bushes, the relation between the potential total crop and the number of penetrated fruits per tree was described satisfactorily by the equation:

$$Y = X\left(1 - e^{-\frac{N}{X}}\right)$$

where Y is observed number of penetrated fruits per tree; X is potential number of fruits per tree (estimated from total numbers of fruit buds in spring); N is number of penetrations per tree (Fig. 1).

This equation is a variant of that used by Nicholson and Bailey[2] to describe random searching. Random search implies that all fruits are equally liable to penetration and that newly hatched larvæ are incapable of avoiding fruits which are already infested or otherwise unsuitable as food. This lack of discrimination intensified contest as population density increases, and makes complete infestation of a crop improbable. Furthermore, the equation postulates that the number of penetrations is similar on all trees of the plot irrespective of size of crop. This does in fact occur when the trees provide a comparable supply of cocoon shelter.

Larval development is completed in the fifth instar. Mature larvæ leave the fruits and seek sites in which to spin a cocoon and pupate. Whereas non-diapausing larvæ are often content to spin a flimsy cocoon in very poor shelter, overwintering individuals search their environment intensively for favourable sites. These occur mainly on the trees, under loose bark and in cracks, wounds and debris. However abundant such sites may be, they are not as a rule found easily by larvæ. Many larvæ fail completely to find adequate shelter and are lost, usually by predation. The favourable overwintering sites are potentially accessible to the remainder, some of which are successful and establish their

hibernacula, while the others are eliminated by competition. This competition is also a form of contest. Except when the density of diapausing larvæ is extremely high, it is less intense than contest for larval food.

The very high levels of crop infestation which prevail in unsprayed orchards can result from remarkably small populations of overwintering larvæ, often no more than ten individuals per mature tree. These populations do not vary much from year to year, because the amount of cocoon shelter available remains fairly constant. Any variations which do arise in overwintering populations, following fluctuations in the size of the preceding crop, are damped by the contest for larval food resulting from random searching. Very dense populations in the early summer are thus prevented from destroying the fruit crop prematurely, and, consequently, from suppressing completely the diapausing larvæ which are produced later in the season. In this way, codling moth populations can very nearly exhaust their seasonal supply of larval food each year without the risk of attaining self-destructive densities.

The principal density-governing factor regulating codling moth abundance is the availability of previously uninfested fruits to newly hatched larvæ. The availability of favourable shelter to diapausing larvæ acts as a complementary governing factor[3].

MacLellan's[4] work on the destruction of overwintering codling moth populations by woodpeckers in eastern Canada and the resulting low levels of summer infestation suggests that similar effects could be achieved in Australia in a different way, namely, by bringing cocoon shelter into very short supply. For this to be effective, cocoon shelter would have to be reduced to such an extent that it became the principal governing factor in the numerical regulation of codling moth. Experiments are in progress to test the feasibility of this approach for Australian conditions.

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A full account of this work will be published elsewhere.

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BACTERIOLOGY

Aspects of the Conversion of Glucose to α-Ketoglutarate in *Acetobacter melanogenum*

Glucose oxidation in extracts of *Acetobacter melanogenum* has been shown to result in the formation of pyruvate[1] through reactions involving the pentose phosphate cycle and the Entner–Doudoroff splitting reaction[2]; glucose is also oxidized to 2,5-diketogluconate[3] and then to α-ketoglutarate[4]. In a previous paper[5], evidence was given for the functioning of only certain portions of the tricarboxylic acid cycle in *A. melanogenum*. It was also shown that these cells did not synthesize four carbon compounds from one-, two- or three-carbon precursors. It was, therefore, of interest to study the contribution of the various pathways in the synthesis of α-ketoglutarate from glucose in washed cell suspensions of *A. melanogenum*.

The isolation and assay of radioactive compounds and methods of preparing washed cell suspensions have been described[5]. Cells oxidizing specifically labelled glucose-^{14}C release amounts of $^{14}CO_2$ which differ according to the position of the labelled carbon (Table 1). The $^{14}CO_2$ values are consistent with the operation of a pentose phosphate cycle, Entner–Doudoroff splitting reaction and part of the glycolytic pathway[1]. Dinitrophenol almost completely inhibits the release of $^{14}CO_2$ from the differently labelled ^{14}C-glucose (Table 1), whereas the oxygen uptake in this experiment is only inhibited to the extent of 22 per cent. These results indicate a dichotomy in the oxidative degradation of glucose. As dinitrophenol is an inhibitor of oxidative phosphorylation[6], its presence decreases the supply of adenosine triphosphate necessary for the breakdown of glucose by enzymes of the phosphorylated pathways. This results in nearly maximal inhibition of the conversion of glucose-^{14}C to $^{14}CO_2$. The small amount of $^{14}CO_2$ released in the presence of dinitrophenol may be due to endogenous supplies of adenosine triphosphate regenerated by glycolytic enzymes and to the conversion of glucose to 2,5-diketogluconate, followed by its slow decarboxylation[7] with the eventual formation of α-ketoglutarate[4]. The latter sequence of reactions is not inhibited by dinitrophenol in extracts of *A. melanogenum*[4], and seems to be the main route of oxygen uptake during glucose oxidation by cells.

Table 1. Effect of Dinitrophenol on the Oxidation of Glucose-1-, -2-, -6-^{14}C and -U-^{14}C by *A. melanogenum*

System	$^{14}CO_2$ formed (counts per min.)		Inhibition due to dinitrophenol (per cent)
	Dinitrophenol absent	Dinitrophenol present	
Glucose-1-^{14}C	14,650	710	95
Glucose-2-^{14}C	6,330	140	98
Glucose-6-^{14}C	7,420	400	95
Glucose-U-^{14}C*	12,690	210	98

* Uniformly labelled glucose.

Components of reaction mixtures in 2·4 ml.: potassium phosphate buffer, pH 7·4, 120 μmoles; ^{14}C-labelled glucoses, 10 μmoles, (20,000 c.p.m./μmoles); dinitrophenol, 12 μmoles; cells, 0·8 gm. wet weight. Duration of experiment, 10 min. Temperature, 30° C.

Cells oxidizing glucose-U-^{14}C rapidly incorporate radioactivity into α-ketoglutarate as compared with pyruvate (Fig. 1). The specific activity of α-ketoglutarate reaches a maximum value which is similar to that obtained on a theoretical basis, assuming that it is formed from glucose with the loss of one carbon atom. It is interesting that the specific activity of pyruvate is low. This may be due to non-equilibration of the pyruvate pool with radioactive pyruvate, a phenomenon which has been demonstrated[5] when *A. melanogenum* cells were incubated with pyruvate-2-^{14}C.

Fluoroacetate (3×10^{-3} *M*) and dinitrophenol (5×10^{-3} *M*) had no effect on the kinetics of formation of radioactive α-ketoglutarate and pyruvate (Fig. 1). Fluoroacetate is known to inhibit aconitase in animal

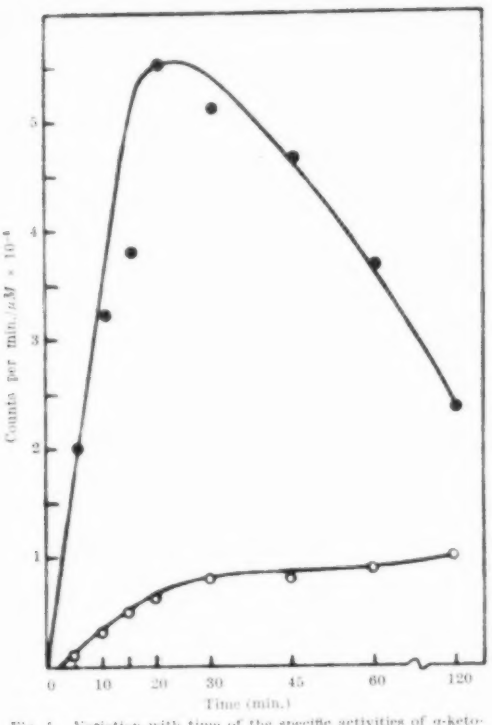

Fig. 1. Variation with time of the specific activities of α-ketoglutarate (—●—) and pyruvate (—○—) formed from glucose-U-^{14}C by resting cell suspensions. Reaction mixture contained in 10 ml.: potassium phosphate buffer, pH 7·4, 500 μmoles; glucose-U-^{14}C, 15 μmoles (666,000 counts per min./μmole); cells, 3·3 gm. wet weight. Temperature 30° C.

tissues[8]. In *A. melanogenum* its use results in a two-fold increase of radioactive citrate in cells oxidizing acetate-1-^{14}C.

From the results of these experiments, the conclusion may be drawn that α-ketoglutarate is formed in washed cell suspensions of *A. melanogenum* by the pathway involving non-phosphorylated intermediates (that is, gluconate and 2,5-diketogluconate[3,4]). This synthetic route is also consistent with the observations[5] on the lack of synthetic enzymes for the net formation of α-ketoglutarate from pyruvate in the tricarboxylic acid cycle.

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Folinic Acid Requirement of Strains of the Genus *Pediococcus*

Until some ten years ago, the genus *Pediococcus* was recognized only in the brewing industry, but strains of *Pediococcus cerevisiae* are now known to occur commonly in other food products[1,2]. It has been suggested that strains of the genus isolated earlier were not always correctly identified, and were classified as either leuconostocs or micrococci, according to their catalase reaction[3]. Therefore, any test which would help to identify the genus or the species *Pediococcus cerevisiae* would be useful. Felton and Niven[4] suggested that a requirement for folinic acid might be a generic character of the pediococci. However, they examined only typical strains of *Pediococcus cerevisiae* and, while it is true that a majority have this requirement, strains without it are known[5].

Recently four strains of *Pediococci* (*N.C.D.O.* 1247, 1248, 1249 and 1250; that is, *I.*354, *S*190, *I.*22 and *S*344 respectively) were deposited in the National Collection of Dairy Organisms by Dr. H. L. I. Gunther, of Queen Elizabeth College, University of London, and these were reported to vary in several respects from the typical *Pediococcus cerevisiae*[6].

They were therefore examined for their folinic acid requirement in the synthetic medium used for the assay of folinic acid with *Pediococcus cerevisiae* *ATCC* 8081[7]. All four strains failed to grow even when folinic acid was present, and under conditions which supported normal growth of *ATCC* 8081. It was found that certain additions to the assay medium and sometimes modified cultural conditions were necessary before all the strains would grow.

The strains were sub-cultured in tomato glucose broth in which three of them, *N.C.D.O.* 1247, 1248 and 1249, grew well aerobically and also anaerobically. The fourth strain, *N.C.D.O.* 1250, failed to grow except under anaerobic or reducing conditions, and good growth of this strain has not been obtained aerobically in any medium. Therefore, for *N.C.D.O.* 1250, 0·5 ml. of a 1 per cent w/v solution of ascorbic acid, sterilized by Seitz filtration, was added to each 10 ml. of medium before inoculation, and the tubes incubated aerobically.

'Tween 80', an ingredient of the tomato glucose broth, was found to be essential for the growth of all four strains, although Kitay and Snell[8] found that *ATCC* 8081 did not require it. Two of the strains, *N.C.D.O.* 1247 and 1250, grew well when 'Tween 80' (0·001 ml./10 ml.) was added to the Sauberlich and Baumann medium containing folinic acid.

Charcoal-treated tryptic digest of casein solution was prepared according to Roberts and Snell[9] and added to the assay medium, at a level of 1 ml./10 ml. Under these conditions all the strains grew well. It appears that, as with other strains within the Lactobacilliaceae[10], *N.C.D.O.* 1248 and 1249 require a peptide in addition to the amino-acids and other growth factors supplied.

A solution containing vitamin-free acid-hydrolysed casein, tryptophan, phenylalanine, histidine, tyrosine and cystine could replace the amino-acid mixture in the original medium, but the addition of the tryptic digest of casein was still necessary.

The folinic acid requirement of the strains was examined in this modified medium, adding only one level, 0·1 μgm./10 ml. The composition of the medium and the techniques used for the growth tests have been

described by Garvie, Gregory and Mabbitt[11]. Since a variety of strains and possibly more than one species were being examined, the growth of each strain was observed after 24- and 48-hr. incubation at 30° C. in the medium with and without folinic acid. Two of the strains, *N.C.D.O.* 1250 and 1247, grew equally well in all tubes and had no requirement for folinic acid. The other strains, *N.C.D.O.* 1248 and *N.C.D.O.* 1249, gave excellent growth in the presence of folinic acid at 24 hr., but none in its absence. However, at 48 hr. in the absence of folinic acid, growth sometimes occurred. Thus, with these strains, folinic acid has a marked stimulatory effect on growth, although under conditions at present undefined, they grew in its absence, but only after a prolonged lag phase. The control, *ATCC* 8081, showed no growth in the absence of folinic acid after 48 hr. incubation.

These results show that a requirement for folinic acid is not restricted to typical strains of *Pediococcus cerevisiae*. Until more strains have been examined, it is not possible to decide if the growth requirements which have been discussed are useful in classification, or if they demonstrate merely variations within the species *Pediococcus cerevisiae*.

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[8] Kitay, E., and Snell, E. E., *J. Bact.*, **60**, 49 (1950).
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A Bacteriophage for Motile Bacteria

In the first stage of phage infection, the phage particle is adsorbed to a specific receptor which is usually on the bacterial body[1]. However, an exceptional phage has been reported[2] the host-range of which appeared to be determined by flagella, and these are structurally distinct from the bacterial surface proper[3].

Four conditions have now been found to determine bacterial sensitivity to this *Salmonella* phage, named χ.

(1) The bacteria must be flagellated. Non-flagellated strains are invariably resistant, and resistant non-flagellated variants are selected from sensitive strains by the phage.

(2) The flagella must carry certain antigens. Sensitivity was shown to depend on the flagellar (*H*) antigen, and not on the somatic (*O*) antigen, by tests on (*a*) 524 naturally occurring motile *Salmonella* strains belonging to 27 different *O* groups and carrying most of the known *H* antigens; and (*b*) sets of artificial derivatives of single strains, differing in their *H* antigens, which had been prepared by phage-mediated transduction[4]. Strains with most *H* antigens could be sensitive, but all 53 naturally occurring strains with antigens of the *g* complex (*g,m, g,p, g,s,t*, etc.) were resistant: transduction of antigen *g* . . . to sensitive strains made them resistant and resistant strains naturally carrying *g* . . . were often sensitive when another antigen was substituted. The wild-type phage did not attack strains with *H* antigen *l* . . . (*l,z*$_{13}$, *l,v*, or *l,w*), but could mutate to a form able to do so. Host-range mutants were also isolated for bacteria with *H* antigens *e,h* and Arizona 13. Diphasic strains carrying *g* . . . , *l* . . . or *e,h* in one phase could be sensitive to wild-type phage in the alternate phase.

(3) The flagella must be active: 10/10 naturally occurring paralysed (that is, flagellated but non-motile) strains were resistant while their motile derivatives were sensitive. Also, 8/80 resistant variants selected by the χ phage from sensitive strains turned out to be paralysed. Reversion to motility was accompanied by return of sensitivity.

(4) The bacterial strain itself must be suitable, for not all motile bacteria with appropriate *H* antigens were sensitive. The importance of the bacterial strain was clearly seen with transduction of an antigen, for the strain from which the antigen had been transduced often reacted differently from the recipient.

Resistance due to absent or inactive flagella, or to flagella of inappropriate antigenic type, could be shown to be associated with impaired adsorption of the phage, by using sets of variants of suitable strains. Adsorption was prevented by detaching the flagella from sensitive bacteria, and returned progressively to normal as the flagella were regenerated. Adsorption was also impaired when sensitive bacteria were artificially paralysed by treatments such as thorough washing, or exposure to 2,4-dinitrophenol.

No adsorption to detached flagella was detected, probably because they were inactive.

Electron micrographs, kindly prepared by Mrs. H. Ozeki and by Dr. E. H. Mercer, showed phage particles attached by the tips of their tails all along the length of the flagella; none was seen on flagella carrying antigens associated with resistance and few or none were found on paralysed bacteria. Other experiments showed that infection could follow adsorption to distal as well as proximal parts of a flagellum.

If, as it appears, isolated[5] and paralysed[6] flagella are structurally similar to active flagella, then the latter do not seem to possess any unique structure that might be the phage receptor. The necessity for flagellar movement to promote phage infection may thus mean that the activity is necessary in itself and not merely a concomitant of a new flagellar structure. The means by which the phage genome passes from its primary site of adsorption on a flagellum to the bacterial body is not clear, but the flagella do not seem to act merely by 'activating' the phage so that it can attach itself to the bacterial body afterwards. These points and the detailed results are discussed elsewhere.

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[1] Burnet, F. M., *J. Path. Bact.*, **33**, 647 (1930).
[2] Sertic, V., and Boulgakov, N. A., *C.R. Soc. Biol., Paris*, **123**, 887 (1936).
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[5] Astbury, W. T., Beighton, E., and Weibull, C., *Symp. Soc. Exp. Biol.*, **9**, 282 (Cambridge University Press, 1955).
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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, May 8

UNIVERSITY OF LONDON (at the Wright-Fleming Institute of Microbiology, St. Mary's Hospital, Paddington, London, W.2), at 5 p.m.—Dr. S. Brenner: "Bacteriophage Growth".*

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5 p.m.—Prof. A. Neuberger, F.R.S.: "The Biosynthesis of Porphyrins and Chlorophylls".* (Further lecture on May 11.)

INSTITUTION OF ELECTRICAL ENGINEERS, ELECTRONICS AND COMMUNICATIONS SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Scientific Papers.

UNIVERSITY OF LONDON (at the School of Pharmacy, 29–39 Brunswick Square, London, W.C.1), at 5.30 p.m.—Prof. L. W. Busse (Wisconsin): "Some Aspects of Percutaneous Absorption".*

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 6 p.m.—Mr. Basil Taylor: "The Presentation of Visual Arts". (Second of three Cantor Lectures on "The Presentation of Science and the Arts on Television".)

ROYAL AERONAUTICAL SOCIETY, HISTORICAL GROUP (at 4 Hamilton Place, London, W.1), at 7 p.m.—"A Quiz on Little Known Early Aircraft".

Tuesday, May 9

SOCIETY OF CHEMICAL INDUSTRY, AGRICULTURE GROUP (at 14 Belgrave Square, London, S.W.1), at 10.30 a.m.—Annual General Meeting, followed by a full-day Meeting on "Manuring of Tropical Crops".

ASLIB (in the Lecture Theatre of the Royal Aeronautical Society, 4 Hamilton Place, London, W.1), at 2.30 p.m.—Discussion on "The National Reference Library of Science and Invention".

ZOOLOGICAL SOCIETY OF LONDON (at the Zoological Gardens, Regent's Park, London, N.W.1), at 5 p.m.—Scientific Papers.

UNIVERSITY OF LONDON (at the School of Pharmacy, 29–39 Brunswick Square, London, W.C.1), at 5.30 p.m.—Prof. L. W. Busse: "Electronic Analysis of Emulsion Globules".*

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7 p.m.—Mr. M. E. Burt: "Structural Weight Estimations for Novel Configurations".

Wednesday, May 10

UNIVERSITY OF LONDON (in Lecture Room 102, Chemical Engineering Department, Imperial College of Science and Technology, London, S.W.7), at 4 p.m.—Prof. Gabriel Stein: "Recent Advances in the Radiation Chemistry of Aqueous Systems—Part II, Some Systems of Biochemical Interest".*

INSTITUTION OF ELECTRICAL ENGINEERS, SUPPLY SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Dr. M. Datta: "Electricity Supply in India and its Future".

UNIVERSITY COLLEGE LONDON (in the Physiology Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. P. Balint (University of Budapest): "The Reliability of Clearance Tests in the Evaluation of Renal Blood Flow".*

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. P. D. Bartlett (Harvard): "Peresters and Homolytic Fragmentation".*

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 6 p.m.—Mr. J. S. Fulton: "The Future Pattern of University Education in the United Kingdom".

Wednesday, May 10—Thursday, May 11

ASSOCIATION FOR THE STUDY OF MEDICAL EDUCATION (in the New Hall of the Students Hostel, London Hospital Medical College, Ashfield Street, Whitechapel, London, E.1)—Symposium on "Closed-Circuit Television in the Medical School".

Thursday, May 11

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. P. D. Bartlett (Harvard): "Autoxidation and Chain Termination".*

SOCIETY OF INSTRUMENT TECHNOLOGY, CONTROL SECTION (at Manson House, 26 Portland Place, London, W.1), at 6.15 p.m.—Annual General Meeting, 7 p.m.—Dr. W. Grey Walter: "Control Mechanism in the Human Nervous System".

Friday, May 12

BRITISH INTERPLANETARY SOCIETY (in the Council Room of the Federation of British Industries, 21 Tothill Street, London, S.W.1), at 10 a.m.—Symposium on "Communications Satellites".

INSTITUTION OF ELECTRICAL ENGINEERS, EDUCATION DISCUSSION CIRCLE (at Savoy Place, London, W.C.2), at 6 p.m.—Discussion on "The Place of Transistors in National Certificate Courses", opened by Mr. B. F. Gray and Mr. W. B. K. Ellis.

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. T. Stanley Westoll, F.R.S.: "A Crucial Stage in Vertebrate Evolution: Fish to Land Animal".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER OR ASSISTANT LECTURER (preferably with special interests or qualifications in igneous and metamorphic petrology) IN THE DEPARTMENT OF GEOLOGY—The Registrar, The University, Leeds 2 (May 12).

POSTDOCTORAL FELLOW IN ORGANIC CHEMISTRY, to carry out researches into the behaviour of olefinic acids in strong acid media in collaboration with Dr. M. F. Ansell—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (May 12).

LECTURER IN THE DEPARTMENT OF METALLURGY—The Registrar, The University, Liverpool (May 15).

ASSISTANT LECTURER IN APPLIED MATHEMATICS—The Secretary, The Queen's University, Belfast (May 20).

HARRY BOLUS CHAIR OF BOTANY in the University of Cape Town, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa and London, May 20).

LECTURER IN CHEMICAL ENGINEERING—The Registrar, University College, Singleton Park, Swansea (May 20).

LECTURER (preferably with an interest in ecology and/or meteorology and climatology) IN THE DEPARTMENT OF GEOGRAPHY—The Secretary, The University, Aberdeen (May 20).

SENIOR LECTURER IN THE DEPARTMENT OF PHYSICS—The Assistant Registrar (Science), The University, Edgbaston, Birmingham 15 (May 24).

LECTURER (preferably with research experience in plant–insect relations or a related field) IN THE DEPARTMENT OF HORTICULTURE, to teach biological aspects of horticultural crop protection—The Registrar (Room 22, O.R.B.), The University, Reading (May 31).

LECTURER (with a higher degree, preferably a Ph.D., and preferably experience in university teaching) IN CHEMISTRY at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, May 31).

RESEARCH FELLOW IN CHEMICAL CRYSTALLOGRAPHY IN THE DEPARTMENT OF CHEMISTRY in the Faculty of Science to undertake investigations into the structures of complex natural products of biological importance and novel structural interest—The Registrar, University of Manchester, Manchester 13 (May 31).

SENIOR LECTURER IN INORGANIC CHEMISTRY—The Secretary, Royal College of Science and Technology, George Street, Glasgow, C.1 (May 31).

SENIOR PRINCIPAL SCIENTIFIC OFFICER (research worker with specialized knowledge and experience in animal research)—The Secretary, Hill Farming Research Organization, 48 Palmerston Place, Edinburgh 12 (May 31).

LECTURER (preferably with experience in plant physiology or developmental anatomy) IN BOTANY at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong and London, June 2).

LECTURER/SENIOR LECTURER (interested and qualified in mineralogy and crystallography, and preferably with experience in X-ray techniques) IN GEOLOGY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, June 9).

LECTURER IN EDUCATION; and LECTURERS (2) IN GEOGRAPHY at the University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, June 15).

CHAIR OF PHYSICS (High Energy Nuclear Physics) in the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, June 30).

BIOCHEMIST (non-medical) IN THE DEPARTMENT OF MEDICINE, Makerere University College, East Africa, to participate in the current programme of research—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1.

CHAIR OF PHYSICS in the Royal University of Malta—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1.

CHEMIST OR BIOCHEMIST (honours graduate), to investigate fundamental aspects of the dehydration of meat—The Director, Low Temperature Research Station, A.R.C., Downing Street, Cambridge.

HEAD, Senior Scientific or Principal Scientific Officer (with a good honours degree in science or equivalent and previous research experience), OF THE PIG SECTION OF THE APPLIED NUTRITION DEPARTMENT—The Secretary, Rowett Research Institute, Bucksburn, Aberdeen.

LECTURER, and a LECTURER (Grade B) IN THE DEPARTMENT OF MATHEMATICS—The Secretary, Northampton College of Advanced Technology, St. John Street, London, E.C.1.

LECTURER IN PSYCHOLOGY at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1.

MEDICAL LABORATORY TECHNICIAN (qualified A.I.M.L.T., science degree or equivalent)—The Administrative Office, North London Blood Transfusion Centre, Deansbrook Road, Edgware, Middlesex.

OTTO BEIT CHAIR OF PHYSIOLOGY; SENIOR LECTURERS IN THE DEPARTMENT OF PHYSIOLOGY; LECTURER IN THE DEPARTMENT OF PATHOLOGY AND MICROBIOLOGY; a SENIOR LECTURER and LECTURER IN THE DEPARTMENT OF MATHEMATICS; and a SENIOR LECTURER and LECTURER IN PHYSICAL CHEMISTRY at the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1.

RESEARCH ASSISTANT (graduate) IN THE MATHEMATICS DEPARTMENT, to work either in computing, mathematics or statistics—The Secretary, Northampton College of Advanced Technology, St. John Street, London, E.C.1.

RESEARCH FELLOW or ASSISTANT (with a good honours degree in mathematics or engineering, and preferably experience in program-

ming for a digital computer) IN THE DEPARTMENT OF AERONAUTICS AND ASTRONAUTICS for work in the field of hypersonic gas dynamics—The Secretary and Registrar, The University, Southampton.

SENIOR LECTURER (graduate in botany, agriculture or horticulture, with teaching and research experience at university level, and preferably a knowledge of tropical crops) IN CROP HUSBANDRY at the University College of the West Indies (Imperial College of Tropical Agriculture, Trinidad)—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1.

SENIOR LECTURER or LECTURER IN ORGANIC CHEMISTRY; a LECTURER IN INORGANIC CHEMISTRY; and an ASSISTANT LECTURER IN INORGANIC CHEMISTRY—The Academic Registrar, Loughborough College of Technology, Loughborough, Leicestershire, quoting Ref. 9/6.

SENIOR LECTURER (qualified to teach microbiology to final degree and Diploma of Technology standard) IN MICROBIOLOGY IN THE DEPARTMENT OF BIOLOGICAL SCIENCES—The Registrar (Department F), Bradford Institute of Technology, Bradford 7.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Government of Northern Ireland: Ministry of Agriculture. Leaflet No. 16: Feeding Dairy Cows. Pp. 15. Leaflet No. 84: Lime and Liming. Pp. 7. Leaflet No. 100: The Cultivation of Carrots. Pp. 8. Leaflet No. 107: Mineral Mixtures for Stock-Feeding. Pp. 4. Leaflet No. 142: Lead and Copper Poisoning. Pp. 4. (Belfast: Ministry of Agriculture, 1960 and 1961.) [172

Notes on Process Selection and Filler/Electrode Materials. (Addendum 2 to Information Bulletin 13.) Pp. 7. (London: The Aluminium Development Association, 1960.) [172

Agricultural Research Council. Postgraduate Studentships and Fellowships offered in 1961. Pp. 20. (London: Agricultural Research Council, 1961.) [172

Committee of Vice-Chancellors and Principals of the Universities of the United Kingdom. Third Report of an *ad hoc* Committee on Procedure for Admission of Students. Pp. v + 41. (London: Committee of Vice-Chancellors and Principals of the Universities of the United Kingdom, 1961.) 2*s.* 6*d.* [172

Department of Scientific and Industrial Research: National Physical Laboratory. Notes on Applied Science No. 20: Small-Scale Preparation of Fine-Grain (Colloidal) Photographic Emulsions. By B. H. Crawford. Pp. iv + 13 + 1 plate. (London: H.M. Stationery Office, 1960.) 1*s.* 6*d.* net. [172

The Engineer Buyers Guide, 1961. Pp. 984. (London: Morgan Brothers (Publishers), Ltd., 1961.) 10*s.* [172

English Electric Valve Co., Ltd. Abridged Valve Data. Pp. 38. (Chelmsford: English Electric Valve Co., Ltd., 1961.) [172

The Consolidated Zinc Corporation, Ltd. Descriptive Booklet. Pp. 96. (London: The Consolidated Zinc Corporation, 1960.) [172

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 1028, Vol. 253 (9 February, 1961): Ionization Fronts in Interstellar Gas and the Expansion of H II Regions. By F. A. Goldsworthy. Pp. 277–300. 7*s.* 6*d.* No. 1029, Vol. 253 (9 February, 1961): Ionization Fronts in Interstellar Gas: The Structure of Ionization Fronts. By W. I. Axford. Pp. 301–333. 10*s.* 6*d.* (London: Royal Society, 1961.) [172

Liverpool Observatory and Tidal Institute. Annual Report, 1960. Pp. 20. (Liverpool: Liverpool Observatory and Tidal Institute, 1961.) [172

Government of Northern Ireland: Ministry of Agriculture. Leaflet No. 82: The Production of Clean Milk. Pp. 19. Leaflet No. 146: The Growing and Harvesting of Ryegrass Seed. Pp. 4. (Belfast: Ministry of Agriculture, 1961.) [172

Bulletin of the British Museum (Natural History). Botany, Vol. 2, No. 10: New Species of *Taeniacoon* from the Himalayan Region. By J. L. van Soest. Pp. 261–273 + plates 22–29. 10*s.* Zoology, Vol. 7, No. 4: A Revision of the Genus *Dinotopterus* Bigr. (Pisces, Claridae), with Notes on the Comparative Anatomy of the Suprabranchial Organs in the Claridae. By P. H. Greenwood. Pp. 215–241. 10*s.* (London: British Museum (Natural History), 1961.) [172

Building Research Station Digest (Second Series), No. 7: Noise in the Home. Pp. 4. (London: H.M. Stationery Office, 1961.) 4*d.* [172

University of Birmingham. Report of the Proceedings of the Council of the University for the year ended 31st December, 1960. Pp. 19. Accounts for the year ended 31st July, 1960. Pp. 35. Report of the Vice-Chancellor and Principal for the calendar year 1960. Pp. 35. University Research Committee—Thirty-first Annual Report (Session 1959–60). Pp. 137 + 1 plate. (Birmingham: The University, 1960, and 1961.) [172

Agents of Cultural Advance. By Sir Aubrey Lewis. (L. T. Hobhouse Memorial Trust Lecture No. 30, delivered on 30 April, 1960, at University College, London.) Pp. 29. (London: Oxford University Press, 1961.) 5*s.* net. [172

Other Countries

Ministry of Agriculture and Lands, Jamaica, W.I. Bulletin No. 57 (New Series): Investigations, 1956–1957. Pp. iii + 139. 3*s.* 6*d.* Black Pepper: a Review of Cultural Practices and their Application to Jamaica. By J. F. Ward. Pp. i + 13. Veterinary Division Extension Circular No. 61 (August, 1959): Swine Erysipelas. Pp. 7. (Kingston: Government Printer, 1959 and 1960.) [311

United States Department of the Interior: Geological Survey. Professional Paper No. 365: Apparent Resistivity of a Single Uniform Overburden. By L. Roman. Pp. iv + 99. (Washington, D.C.: Government Printing Office, 1960.) 70 cents. [311

Koninklijk Nederlands Meteorologisch Instituut. Mededelingen en Verhandelingen. No. 67: Climatological Data of the Netherlands Light-Vessels over the period 1910–1940. By G. Verploegh. Part 3: Temperatures and Hydrometeors: Thunderstorms. Pp. 146. 18 florins. No. 74: Geostrophic Flow: Geostrophic Approximation in the Upper Air Flow, with Application to Aeronavigation and Air Trajectories. By Dr. H. M. de Jong. Pp. 100. 5 florins. No. 75: A New Analysis of some Features of the 11-year and 27-day Cycles in Solar Activity and their Reflection in Geophysical Phenomena. By Dr. S. W. Visser. Pp. 65. 3.50 florins. No. 76: Fault Plane Mechanisms of Southeast Asian Earthquakes. By A. R. Ritsema and J. Veldkamp. Pp. 63. 4 florins. (De Bilt: Koninklijk Nederlands Meteorologisch Instituut, 1959 and 1960.) [12

Bulletin of the Astronomical Institutes of the Netherlands. Vol. 15, No. 499 (1960, December 30): Methods for Computing the Original Orbits of Comets. By E. H. Bilo and H. V. van de Hulst. Definitive Elements for Comets 1905 IV (Kopff), 1941 VIII (vanGent), 1946 I (Timmers), and 1946 VO (Jones). By G. Peis. The Original Values of $1/a$ for 17 Cometary Orbits. By E. H. Bilo and I. Van Houten-Groeneveld. Pp. 119–164. Vol. 15, No. 500 (1960, December 30): Formation and Evolution of Clusters of Galaxies. By G. B. van Albada. Pp. 165–198. Vol. 15, No. 501 (1960, December 30): Three-Colour Photometry in the *U*, *B*, *V* System of 51 Northern Cepheids. By P. Th. Oosterhoff. Pp. 199–228. Vol. 15, No. 502 (1960, December 30): Dynamic Spectra and Polarization of Small Bursts in Solar Radio Emission. By T. de Groot. Pp. 229–236. Vol. 15, No. 503 (1960, December 30): Temperature Determinations for Nuclei of Thirteen Planetary Nebulae. By H. Zanstra. Stellar Temperature from He I Emission and the Ultraviolet and Visual Star Spectrum. By L. H. Aller and H. Zanstra. Pp. 237–250. Vol. 15, No. 504 (1960, December 30): A.D.C. Amplifier for Photoelectric Photometry. By J. Borgman. Seven-Colour Photometry of O, B and A Stars. By J. Borgman. Pp. 251–263. (Leiden: Bulletin of the Astronomical Institutes of the Netherlands, 1960.) [12

Annual Report of the Geological Survey Department, British Territories in Borneo for 1959. By F. W. Roe. Pp. xii + 219 + 46 plates. (Kuching, Sarawak: Government Printer, 1960.) 3 Malayan dollars; 7*s.* [172

University of Florida: Florida State Museum. Director's Report, 1959–1960. Pp. 19 + 2 plates. (Gainesville, Fla.: University of Florida, Florida State Museum, 1960.) [172

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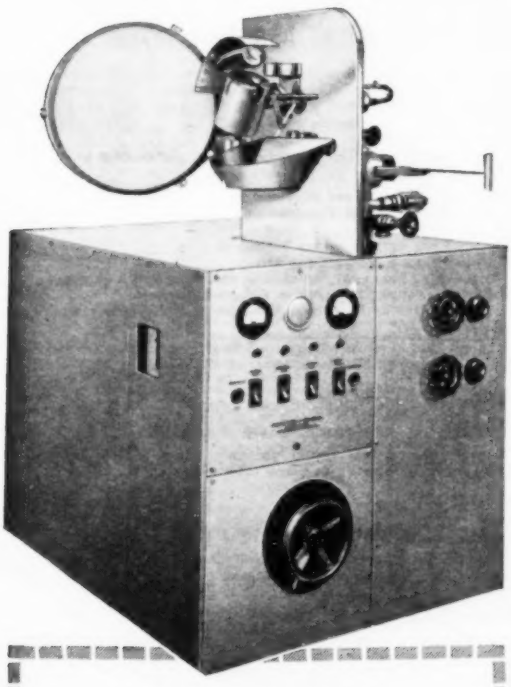

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APPOINTMENTS VACANT

CANCER INSTITUTE BOARD
278 WILLIAM STREET, MELBOURNE, VICTORIA, AUSTRALIA
DEPUTY PHYSICIST-IN-CHARGE

Applications are invited from suitably qualified persons for appointment to the above position. The appointee, who will be responsible to the Physicist-in-Charge, will be required to assist in the general administration of the Physics Department and take an active part in research. Through the Peter MacCallum Clinic, the Board provides a Radiotherapy service for a population of approximately three million in the States of Victoria and Tasmania and carries out specialized research in this field. In addition to conventional X-ray therapy equipment, one 4 MeV linear accelerator is in operation in Melbourne and the installation of a second will commence shortly. A theratron junior (Cobalt-60) unit is in use in Launceston, Tasmania. The responsibilities of the Physics Department include the provision of a medical physics service to clinical and special departments, the radiation protection of personnel and the conduct of research into problems associated with the work of the Institute. There are excellent laboratories and technical workshop facilities are available. Qualifications: Applicants should have a degree in physics and should state their experience in medical physics and electronics. Salary: Salary will be according to qualifications and experience up to a maximum of £A.2,750 per annum. Other conditions of appointment include sick, long service and recreational leave. Superannuation equivalent to the F.S.S.U. scheme is available. Substantial assistance will be given for the payment of fares and removal expenses.

Full conditions of appointment may be obtained from the undersigned, with whom applications, stating age, qualifications and experience, and including the names of at least two referees, close on June 2, 1961.

R. K. CHURCHES,
Manager and Secretary.

CHELSEA COLLEGE OF SCIENCE AND TECHNOLOGY
MANRESA ROAD, LONDON, S.W.3
DEPARTMENT OF PHYSIOLOGY AND PHARMACOLOGY

The Governing Body invite applications for three posts, Senior Lecturer, Lecturer and Assistant (Grade B) in Physiology and in Pharmacology. Honours Degree essential. Duties include teaching and research. The salary scales attached to these grades are as follows: (a) Senior Lecturer, £1,550 by £50 to £1,750; (b) Lecturer, £1,370 by £35 to £1,510 by £40 to £1,550; (c) Assistant (Grade B), £700 by £27 10s. to £1,150, plus additions for training and graduate status. There is, in addition, a London allowance of £38 or £51, according to age. Successful applicants will be placed on these scales in accordance with previous experience and/or industrial experience.

Particulars and form of application from the Clerk to the Governors. Applications to be submitted by May 20, 1961.

ROYAL OBSERVATORY EDINBURGH
EXPERIMENTAL OFFICERS

Applications are invited for the following posts:

ASTROPHYSICS

1. Experimental Officer (Male) to take part in research programmes in stellar photometry and spectroscopy. Emphasis is placed on night work for which an allowance is paid; fullest technological facilities provided. Candidates should normally have university degree in physics or mathematics.

SEISMOLOGY

2. Electronics and Instrument Engineer (Experimental Officer) to take part in research programmes in a new group working on new instrumentation and digital data-handling in seismology. Candidates should normally be university graduates or graduate members of a professional institute in physics or electrical or mechanical engineering or equivalent. Versatility and ability to work independently are required in this now rapidly evolving subject.

Age: 26 or over. Salary: £1,087 to £1,336, commencing at minimum. Posts are unpensionable in first instance, but opportunities to gain pensionable posts will occur.

Further particulars and application forms from Establishment Officer, Scottish Home Department, Room 364, St. Andrew's House, Edinburgh, 1. Closing date May 23, 1961.

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF DEFENCE

STAFF REQUIRED
FOR
ADVANCED EDP SYSTEMS
DESIGN, DEVELOPMENT AND APPLICATION.

An EDP Proving and Training Centre is to be set up in the Australian Department of Defence at Canberra, A.C.T., to introduce large-scale, integrated EDP systems of advanced design into the Navy, Army and Air Force. This Centre is to develop and prove these systems in sequence commencing with that for the Air Force, and is to train staff for their effective operation.

A number of vacancies exist in this Centre and the Services organisations for experienced staff of various specialisations in the following fields:

EDP Systems Analysis, Design and Development.
Programming and Programme Development for Large Digital Computer Configurations.
Data Transmission and EDP Reporting Techniques.
Operations Research using Digital Computers.
Advanced Techniques of Scientific Management and Numerical Analysis.
Supervision and Control of Large Digital Computer Systems.
Supervision and Control of EDP Data Collection and Preparation Staff and Equipment.

Appointments will normally be made within the following classifications, although suitable outstanding applicants may be offered higher classifications:

SENIOR PROGRAMMER
GRADE 2 (£A2,655–2,980) and GRADE 1 (£A2,525–2,720)

At least three years' practical EDP system experience with specialised knowledge and qualifications in one or more of the above fields required.

PROGRAMMERS
GRADE 2 (£A2,265–2,460) and GRADE 1 (£A1,840–2,070)

At least one year of practical EDP system experience with specialised knowledge and qualifications in one of the above fields required.

SENIOR EDP OPERATOR (£A1,563–1,665)

At least three years practical experience in supervising and scheduling the operation of a large-scale digital computer system, or in supervising and controlling specialist data collection and preparation staff, required. Computer programming and coding experience desirable.

On entering into an agreement to remain with the Department of Defence for three years, first-class travel to Canberra will be provided for a successful applicant and his wife and children. A reasonable amount of household goods will also be transported to Canberra where housing or other suitable accommodation will be made available.

Applications, with supporting personal and professional résumés, should be sent to the following address by May 15, 1961. Selected applicants will be interviewed during June, 1961.

The Official Secretary, Australia House, The Strand, London, W.C.2.

UNIVERSITY COLLEGE
IBADAN, NIGERIA

Applications are invited for (A) Senior Lectureship or (B) Lectureship in Soil Science in Department of Agriculture. Knowledge of tropical soils an advantage. Appointment to commence October, 1961, if possible. Salary scales: (A) £2,275 by £75 to £2,575 per annum; (B) £1,200 by £75 to £1,650 (bar), £1,725 by £75 to £2,175 per annum. Passages paid for appointee, wife, and up to five children under 11 years, on appointment, annual overseas leave, and termination. F.S.S.U., children's, car and outfit allowances. Part-furnished accommodation at rent not exceeding 7.7 per cent of salary.

Detailed applications (six copies), naming three referees, by June 10, 1961, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

KENT COUNTY COUNCIL
KENT EDUCATION COMMITTEE
MEDWAY COLLEGE OF TECHNOLOGY
ASSISTANT LECTURER GRADE B IN MATHEMATICS

Applications are invited from suitably qualified persons for the post of Grade B Assistant Lecturer in Mathematics. Applicants should be graduates, or the equivalent, in mathematics, and be prepared to teach the subject to General Certificate of Education Advanced Level and Ordinary or Higher National Certificate standard. The appointment will date from September 1, 1961; commencing salary on the scale will depend upon training, previous industrial and/or teaching experience.

Application forms and further particulars can be obtained from the Principal, Medway College of Technology, Horsted, Maidstone Road, Chatham, Kent (s.a.e.

GLACIER METAL CO. LTD., Kirkstyle, Kilmarnock,

invite applications for the position of

INORGANIC OR PHYSICAL CHEMIST

An Inorganic or Physical Chemist is required for the Metallurgy Department of the Research and Development Organization.

He will investigate the physical and chemical phenomena which determine the frictional behaviour and wear resistance characteristics of new non-metallic bearing materials.

He will be responsible for deciding his own lines of work within his designated field, and for the design and analysis of his experiments.

He will be a member of a vigorous and expanding research organisation which has already achieved considerable success in the development of new bearing materials.

Applicants must have an Honours or higher degree in Chemistry and have had at least two years postgraduate research experience. Experience in surface chemistry would be a particular advantage.

The preferred age range is 24 to 30 and both men and women are eligible for consideration.

A starting salary up to £1,250 is envisaged.

Applications, containing brief details of age, qualifications, experience and present salary to the Personnel Department, quoting reference 3/RDO/5/50.

RESEARCH ASSISTANT WANTED AT Stoke Mandeville Hospital to help with current research on an immunological project connected with Rheumatoid Arthritis. The person appointed would work directly with the Pathologist undertaking the research. Salary £750 to £1,000 per annum according to qualifications.—Inquiries and applications, giving details of experience and the names of two referees, to the Pathologist, Stoke Mandeville Hospital, Aylesbury, Bucks.

UNIVERSITY OF MANCHESTER
NUFFIELD RADIO ASTRONOMY LABORATORIES

There are vacancies at the Nuffield Radio Astronomy Laboratories at Jodrell Bank, Cheshire, for two Senior Research Assistants to carry out the duties given below: 1. Satellite and rocket experiments to determine the flux, composition radiants and spatial distribution of cosmic dust in the vicinity of the Earth. Successful applicant to take over this project and develop new techniques. 2. Satellite and rocket experiments concerned with investigations of extra terrestrial radio signals over large parts of the r.f. spectrum. Successful applicant to take over this project with ample opportunity for original research. Salaries in the range £800 to £1,000 per annum (with possibility of salaries above the maxima in certain cases). Applicants should hold the degree of Ph.D. in physics or electrical engineering or should have comparable qualifications and experience.

Applications should be sent to the Director, Nuffield Radio Astronomy Laboratories, Jodrell Bank, Lower Withington, Macclesfield, Cheshire.

CHELSEA COLLEGE OF SCIENCE AND TECHNOLOGY
MANRESA ROAD, LONDON, S.W.3
DEPARTMENT OF GEOLOGY
RESEARCH ASSISTANTSHIPS

Applications are invited for two Research Assistantships in the Department (the appointments for which will be made in July). Candidates should possess a degree in Geology, with first- or second-class honours. The successful applicants will prepare as internal students for a higher degree under a Recognized Teacher of the University of London. The posts are tenable for two years but may be extended to three years. The salary will be £400 per annum. The assistants may be required to demonstrate for a maximum of six hours weekly for which an additional payment will be made.

Applicants should indicate the field of research or problem which they would like to investigate. In addition, they should give full particulars of their career and the names of two referees. Applications should be received not later than June 9 by the Clerk to the Governors.

FEDERAL GOVERNMENT OF NIGERIA

SPECIALIST OFFICER
(PLANT BREEDER)

REQUIRED by the Federal Department of Agricultural Research, Moor Plantation, Ibadan, to carry out research on plant breeding with special reference to Kola.

Candidates must possess a university degree in natural science (botany) or applied science (agricultural botany) with first- or second-class honours degree, plus two years' postgraduate experience or training in plant breeding. Candidates should be between the ages of 22 and 30 years. The post is not open to women candidates.

Appointment on contract for two tours of 18 to 24 months in the first instance with prospect of extension. Salary according to qualifications and experience in the scale £1,404 to £2,196 per annum (including Inducement Addition). Gratuity of £150 per annum on satisfactory completion of tour. Outfit allowance of £60 on salaries under £1,741. Free passages for officer and wife. Children's allowances while separated. Liberal home leave on full pay. Income tax at low local rates. Quarters at low rent.

Write for application forms and further particulars, stating briefly age, qualifications and experience, to the Recruitment Attaché, Office of the High Commissioner for Nigeria, Nigeria House, 9 Northumberland Avenue, London, W.C.2, quoting B.3/2.

UNIVERSITY OF READING

Applications are invited for a Lectureship in Geography. Preference may be given to candidates with special interest in Geomorphology.

Further particulars may be obtained from the Registrar (Room 22, O.R.B.), The University, Reading, by whom applications should be received by May 27, 1961.

WOOL RESEARCH ORGANISATION OF NEW ZEALAND (INC.)
DIRECTOR

APPLICATIONS ARE INVITED FOR THE POSITION OF DIRECTOR, WOOL RESEARCH ORGANISATION OF NEW ZEALAND (INC.).

SALARY WILL BE IN THE RANGE OF £3,000-£3,500 STERLING DEPENDING ON QUALIFICATIONS AND EXPERIENCE. A SUBSIDISED SUPERANNUATION SCHEME IS AVAILABLE. REASONABLE TRAVELLING EXPENSES AND FARES TO NEW ZEALAND WILL BE PAID. IT IS DESIRED THAT THE APPOINTEE COMMENCE DUTY ABOUT APRIL 1962.

The newly formed Organisation is an autonomous body financed jointly by the New Zealand Wool Board and Government, and will have an annual income of £100,000. New laboratories are to be built adjacent to a university institution, Canterbury Agricultural College, Lincoln, near Christchurch.

The Director will be expected to plan and organise research into the physical, chemical and biological properties of wool and into other matters related to wool. He will be responsible to the Executive committee, and will be required to develop the Organisation from the initial planning of the laboratories, to the selection of staff, preparation of programmes of research, and dissemination of research findings.

Applicants should have a University degree in science or agriculture, and be experienced in organising and directing research preferably, although not necessarily, in wool science. Applications will be treated in strict confidence and should provide details of age, marital status, nationality, degrees held, names of referees, and full particulars of post graduate experience, and publications. Applications should be addressed to:

The Chairman,
Wool Research Organisation of N.Z. (Inc.).
Box 5115, Wellington, New Zealand.

Further particulars are available from the above, or either the Scientific Adviser, International Wool Secretariat, 18/20 Regent Street, London S.W.1, or the Director, Department of Science and Technology, The Wool Bureau Inc., 360 Lexington Avenue, New York 17, N.Y., U.S.A.

Applications close 31 July 1961

Ferranti Semiconductors

have a vacancy for a

PHYSICAL CHEMIST

possessing a degree or H.N.C. certificate to work in the Company's expanding programme of research into the

EPITAXIAL GROWTH OF SILICON CRYSTALS

The vacancy is at the Company's WYTHENSHAWE laboratories and provides the opportunity for original work in a high-calibre research and development team.

This appointment carries an attractive salary with the benefits of a Staff Pension Scheme and a Dependants Insurance Scheme.

Application forms can be obtained from T. J. Lunt, Staff Manager, Ferranti Limited, Hollinwood, Lancs. Please quote reference AS.

SCIENTISTS
(In Instrumentation)

required by

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

at Dounreay Experimental Reactor Establishment to work with a team investigating reactor instrumentation and control problems. This work involves the study of existing systems and the development of new systems and equipment with particular regard to data reduction and presentation. Opportunities will also exist for the introduction and operation of new equipment in the Dounreay reactors.

Applicants should have at least a second-class honours degree, or equivalent, in physics or electrical engineering (electronics), have at least three years postgraduate research experience and be at least 26 years of age. All applicants should be interested in instrumentation, particularly in the development of equipment for new methods of measurement.

Salary assessed between £1,440 to £1,770 according to qualifications and experience.

Rented housing and house purchase assistance available for married officers living beyond daily travelling distance.

Contributory superannuation. Hostel accommodation available.

Send postcard for application form to Personnel Manager, U.K.A.E.A., E.R.E., Dounreay, Thurso, Caithness, Scotland, quoting reference 221/34.

TECHNICIAN REQUIRED IN THE Inorganic Chemistry Laboratory from middle of July. Main duties will be the maintenance of physical apparatus (electrical and optical) and experience in this field is essential. Scale £450 to £750. Initial salary according to age and qualifications.—Apply in writing as soon as possible to F. M. Brewer, Inorganic Chemistry Laboratory, South Parks Road, Oxford.

ELLIOTT

Automation Analysts

Applications are invited from highly qualified graduates (mathematicians, chemists, physicists) to join a team exclusively devoted to exploring and establishing an adequate conceptual basis for the automation of industrial processes. The Automation Analysis team is a separate department of Elliott Brothers (London) Limited, and its function is to clarify the logical relationships between process variables in complex processes such as are found in oil and chemical industries.

This is largely uncharted territory where much interesting work has to be done. Candidates should be capable of assimilating new knowledge, conceiving useful experiments, and drawing objective conclusions from experimental data.

Applications should be addressed to:

The Personnel Manager (Ref. 347),
ELLIOTT BROTHERS (LONDON) LIMITED,
Elstree Way, Borehamwood, Herts.

FEDERAL GOVERNMENT OF NIGERIA

SPECIALIST OFFICER
(PLANT NEMATOLOGIST)

REQUIRED by the Federal Department of Agricultural Research, Moor Plantation, Ibadan, to carry out the identification and study of plant diseases caused by nematodes, and to devise practical control measures.

Candidates must possess a university degree in natural science (botany or zoology) with first- or second-class honours, plus two years' postgraduate experience or training in the study of plant parasitic nematodes. Candidates should be between the ages of 22 and 30 years of age. The post is not open to women candidates.

Appointment on contract for two tours of 18 to 24 months in the first instance with prospect of extension. Salary according to qualifications and experience in the scale £1,404 to £2,196 per annum (including Inducement Addition). Gratuity of £150 per annum on salaries under £1,741. Free passages for officer and wife. Children's allowances while separated. Liberal home leave on full pay. Income tax at low local rate. Quarters at low rent.

Write for application forms and further particulars, stating briefly age, qualifications and experience, to the Recruitment Attaché, Office of the High Commissioner for Nigeria, Nigeria House, 9 Northumberland Avenue, London, W.C.2, quoting B.16/2.

FEDERAL GOVERNMENT OF NIGERIA

PRINCIPAL FISHERIES RESEARCH OFFICER

REQUIRED by the Federal Fisheries Service, to carry out research on problems connected with the fishing industry in Nigeria, with particular reference to inland fisheries; projects in view include a study of the fish of Lake Chad, and of the Niger fish in relation to the proposed hydro-electric scheme. The officer appointed may also be required to engage in marine research and to carry out headquarters administrative duties. He will supervise the work of recently graduated officers and train them in the conduct of research.

Candidates must possess an honours degree in zoology with at least five years' post-graduate research experience in freshwater biology, fisheries science or a cognate subject. A good record of published work would be expected.

Appointment on contract for two tours of 12 to 24 months in the first instance with prospect of extension. Salary £2,340 (including Inducement Addition) per annum, plus gratuity of £150 per annum for satisfactory service. Free passages for officer and wife. Children's allowances while separated. Liberal home leave on full pay. Income tax at low local rates. Quarters at low rent.

Write for application forms and further particulars, stating briefly age, qualifications and experience, to the Recruitment Attaché, Office of the High Commissioner for Nigeria, Nigeria House, 9 Northumberland Avenue, London, W.C.2, quoting H.1/2.

MENTAL HEALTH RESEARCH FUND FELLOWSHIPS

Applications are invited for Mental Health Research Fund Fellowships from suitably qualified persons wishing to pursue full-time research work bearing on problems of mental health, whether in clinical psychiatry or one of its supporting sciences. Both Junior and Senior Fellowships are offered in the salary ranges £700 to £1,800 and £1,800 to £2,500 plus superannuation. The appointments will be for up to three years in the first instance.

Application forms, which must be returned before October 1, 1961, may be obtained, together with further information, from the Secretary, Research Committee, Mental Health Research Fund, 39 Queen Anne Street, London, W.1 (Tel.: WELbeck 1272).

THE DISTILLERS COMPANY LIMITED

SHIFT SUPERVISORS

The Company wish to appoint a Shift Supervisor in the Pilot Plant Division of their Central Research Department at Tonbridge, Kent.

Candidates, aged not over 40, should hold a degree or equivalent qualification in Chemistry or Chemical Engineering. Production experience is not essential, although some knowledge of plant operation would be an advantage.

The post will involve responsibility for pilot plant operation on a shift basis, and the supervision of a team of process operators.

Write:

STAFF MANAGER
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Quote Ref. 13/61.N.

AUSTRALIA

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

APPOINTMENT OF

OFFICER-IN-CHARGE COMMONWEALTH RESEARCH STATION

The Organization invites applications from applicants of high academic standing and considerable research ability with capacity for leadership for appointment as Officer-in-Charge of the Commonwealth Research Station, Merbein, near Mildura, Victoria.

The Station is concerned with problems of the growth of the vine under irrigated conditions, of the processing of sultanas and of the hydrology of irrigated areas. In general terms, the Station undertakes physiological and agronomic studies of the vine, chemical and physical work on the processing of dried fruits, and basic and practical hydrological work on the movement of water in soils. In addition some work is done on other problems, e.g., of plant breeding and of nematology. The Station is well provided with experimental facilities for growing vine and other crops of actual and potential interest to the Murray Irrigation Areas and has a scientific staff of 11 Research Officers and 4 Experimental Officers; total staff being 47.

The Officer-in-Charge, who will be responsible for guiding the main lines of work to be carried out by the Station within its general terms of reference, should be actively engaged in one aspect of the Station's activities. A person experienced in one field of general botany or plant physiology, or of hydrology or of the chemistry of plants products would be considered. Previous experience with the principal crop of the area is not essential.

Salary: Dependent on qualifications and experience within the range: £A.3,630 to £A.4,127 per annum, though higher salary would be considered for an outstanding candidate.

First-class fares paid. Further particulars of conditions, etc., supplied on application to:

Mr. E. J. Drake, Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2,

to whom applications (quoting Appointment No. 490/100) should be addressed by June 10, 1961.

PUBLIC RELATIONS and INFORMATION OFFICER

The successful applicant will be responsible for press relations, information services, including the library, the production of reports and brochures, the preparation of material for lectures and exhibitions and the reception of visitors.

He will need to have the initiative and personality demanded by a vigorous sponsored research institute—now expanding its operation into new fields.

If the successful candidate is a fluent French and/or German speaker, his duties could also include the contacting of Continental science based organizations.

A salary commensurate with qualifications, experience and ability will be paid. A contributory pension scheme applies.

Application should be made to:

THE DIRECTOR,
ARTHUR D. LITTLE RESEARCH INSTITUTE,
INVERESK GATE, MUSSELBURGH, MIDLOTHIAN.

SENIOR TECHNICIAN REQUIRED FOR the Department of Zoology. Applicants should have experience in general laboratory work, photomicrography and histological techniques. Salary £690 by £25 to £815 plus Supplementary Allowance (up to £50) for approved qualifications. —Write to the Bursar, the University, Sheffield 10.

CHEMICAL RESEARCH TECHNICIAN/Assistant to work on Steroids with team investigating endocrinology in relation to human biology and genetics. Salary Whitley Scale.—Apply, giving two referees, to Dr. J. M. Tanner, Institute of Child Health (University of London), The Hospital for Sick Children, W.C.1.

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

require

Scientific and Experimental Staff

to join a group at A.W.R.E., Aldermaston engaged in research in the following fields:

MASS SPECTROMETRY
RADIOACTIVE DECAY INVESTIGATION
INVESTIGATION AND DEVELOPMENT OF SOLID STATE COUNTERS

Experience in these fields, though desirable, is not essential. It is more important that the applicants should be keen to learn and able to demonstrate initiative. These posts offer excellent opportunities of training in a variety of fields and facilities for part-time study will be available.

Appointments will be made to the Scientific Officer and Experimental Officer classes. For Scientific Officer, applicants should have a first- or second-class honours degree in physics or electronics and for Experimental Officer, a pass degree in physics or chemistry, H.N.C., or equivalent qualification.

Salary: £640 to £1,770 per annum according to age, qualifications and experience.

Superannuation scheme. A house or substantial assistance with house purchase will become available for married officers living beyond daily travelling distance.

Please write for application form to the Senior Recruitment Officer, A.W.R.E., Aldermaston, Berks, quoting ref.: 2959/34.

UNIVERSITY COLLEGE OF GHANA

Applications are invited for (A) Lectureship or (B) Assistant Lectureship in Zoology. Preference given to candidates with special qualifications and interests in Protozoology, or in Ecology of Terrestrial Animals; consideration may also be given to applicants with special qualifications and interests in Cytology and Genetics. Salary scales (under review): (A) £G.1,000 by £G.50 to £G.1,350 by £G.75 to £G.1,800; £G.1,850 per annum. (B) £G.900; £G.950 per annum. Entry point according to qualifications and experience. F.S.S.U. Outfit, family and other allowances. Passages for appointee and family on appointment, leave and normal termination. Part-furnished accommodation at a charge not exceeding 7.5 per cent of salary.

Detailed applications (six copies), naming three referees, by June 15, 1961, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

AUSTRALIA

ANALYST (DAIRY CHEMIST),
HAWKESBURY AGRICULTURAL COLLEGE, RICHMOND, NEW SOUTH WALES
DEPARTMENT OF AGRICULTURE

Commencing salary up to £A.1,960 per annum according to qualifications and experience. Qualifications: Applicants must possess a degree in science or agricultural science, or equivalent qualifications with emphasis on chemistry. Duties: Investigational work associated with dairy factory manufacturing problems. Assisted passage to Sydney available.

Inquiries to and application forms available from the New South Wales Agent-General's Office, 56 Strand, London, W.C.2. Applications close on June 5, 1961.

QUEEN MARY COLLEGE
(UNIVERSITY OF LONDON)

Applications are invited for a Post-doctoral Fellowship in Organic Chemistry (stipend £850 by £50 to £950), tenable for one year in the first instance with possible extension for two further years. The Fellow will be expected to carry out researches into the behaviour of olefinic acids in strong acid media in collaboration with Dr. M. F. Ansell.

Application forms may be obtained from the Registrar, Queen Mary College, Mile End Road, London, E.1. Closing date May 12, 1961.

FEDERAL GOVERNMENT OF NIGERIA

SPECIALIST OFFICER
(SPECTRO-CHEMIST)

REQUIRED by the Federal Department of Agricultural Research, Moor Plantation, Ibadan, to take charge of Spectrochemistry work for analysis of soils and plant materials.

Candidates must possess a university degree in natural science (chemistry or analytical chemistry) with first- or second-class honours, plus two years postgraduate experience or training in relation to spectrochemistry, with special reference to practical physics. Candidates should be between the ages of 22 and 30 years. The post is not open to women candidates.

Appointment on contract for two tours of 18 to 24 months in the first instance with prospect of extension. Salary according to qualifications and experience in the scale £1,404 to £2,196 per annum (including Inducement Addition). Gratuity of £150 per annum on satisfactory completion of tour. Outfit allowance of £60 on salaries under £1,741. Free passages for officer and wife. Children's allowances while separated. Liberal home leave on full pay. Income tax at low local rates. Quarters at low rent.

Write for application forms and further particulars, stating briefly age, qualifications and experience, to the Recruitment Attaché, Office of the High Commissioner for Nigeria, Nigeria House, 9 Northumberland Avenue, London, W.C.2, quoting B.15/5.

THERE ARE VACANCIES AT THE COTTON Silk and Man-made Fibres Research Association, Shirley Institute, Manchester 20, for Graduate Physicists, Engineers or Textile Technologists interested in a career of research and development on textile machinery, to work on fundamental studies, and the application of their results, to the development of improved machines and methods of processing.—Please apply, giving full details, to the Director.

NEW ZEALAND

EDUCATION DEPARTMENT

Applications are invited for the following positions at the New Zealand School of Pharmacy:

SENIOR TUTOR OR TUTOR IN PHARMACEUTICS

Applicants should possess a degree or registrable qualification in pharmacy and have had teaching experience. A postgraduate qualification and/or research experience would be an additional advantage. The appointee will be in charge of all the teaching in pharmaceutics and will be particularly responsible for the teaching of pharmaceutical microbiology.

TUTOR OR ASSISTANT TUTOR IN PHARMACOGNOSY

Applicants should possess a degree or registrable qualification in pharmacy. A postgraduate qualification, teaching or research experience would be an additional advantage. The appointee will be responsible for all the teaching in pharmacognosy and should also be prepared to assist with the teaching of pharmaceutics.

SENIOR TUTOR OR TUTOR IN PHARMACEUTICAL CHEMISTRY

Applicants should possess a degree or registrable qualification in pharmacy and should preferably have had teaching experience. The ability to teach pharmacology would be an additional advantage.

Salary: (operative from April 1, 1961)
Senior Tutor in the range £1,515 to £1,705
Tutor in the range £1,260 to £1,515
Assistant Tutor in the range £910 to £1,260

The scales apply to both male and female staff and the commencing salary will depend on qualifications and experience.

Passages: Steamer fares of up to £165 each for the appointee and his wife, and pro rata for dependent children will be paid.

Incidental Expenses: Up to £35 for a single person and £100 for a married man can be claimed to cover the cost of taking personal effects to New Zealand.

Inquiries, quoting reference number B11/8/9, should be addressed to the High Commissioner for New Zealand, 415 Strand, London, W.C.2, who will supply further details and application forms.

Completed applications to be lodged with this office not later than May 29, 1961.

NOTTINGHAM NO. 1 HOSPITAL MANAGEMENT COMMITTEE
GENERAL HOSPITAL, NOTTINGHAM
(467 Beds)

Junior Biochemist (Basic Grade) required in the Chemical Pathology Laboratory, Nottingham General Hospital. Applicants should hold an appropriate science degree or associateship of the Royal Institute of Chemistry. The salary scales are as follows: (a) With first- or second-class honours degree or A.R.I.C., £730 to £925; (b) other entrants, £650 to £925; (c) after a probationary training period of two years, £925 to £1,150. The salary and conditions of service are as authorized by the Whitley Council.

Applications, stating age, qualifications, together with the names of two referees, should be sent to the Group Secretary, General Hospital, Nottingham.

McMASTER UNIVERSITY
HAMILTON, ONTARIO

Applications are invited for positions in Physical Chemistry and in Inorganic-Analytical Chemistry for September, 1961, or September, 1962. The appointment will be made at a rank and salary appropriate to qualifications. Preference will be given to recent graduates with postdoctoral experience, and in physical chemistry, to applicants whose research interests lie in the field of radiation and/or nuclear chemistry. The Department has excellent facilities for research including a one-megawatt swimming-pool reactor.

Inquiries should be directed to D. B. MacLean, Chairman, Department of Chemistry.

OPERATIONAL RESEARCH

The Army Operational Research Organization require Scientific and Senior Scientific Officers and Assistant Experimental and Experimental Officers.

The Organization is concerned with the application of science and scientific method to study a wide range of Army problems associated, for example, with assessment and potentialities of weapon systems, including guided missiles; development of tactics and conduct of military operations and their logistic support; communications and electronics; and problems related to Man in his military environment—his selection and training and performance as well as man/equipment relationships. Work is varied, interesting and challenging. Provided it is backed by reasonable mathematical ability, the subject in which candidate is qualified is not of major significance. Present staff embraces mathematical, physical, biological, engineering and human scientific disciplines. Of greater importance is an attitude of mind which is stimulated by problems, coupled with qualities of originality and initiative. There is no precedent to the vast majority of our problems, and original research is encouraged. The major establishment at West Byfleet (Surrey) is supported by workshop and appropriate laboratory facilities, including a mathematical laboratory with electronic computer. Smaller teams exist in the War Office and at present in Germany and Singapore.

Minimum qualifications and salary scales are as follows:— Scientific Officer: First- or second-class honours degree or equivalent. Salary £738 rising by 14 annual increments to £1,222 (but promotion to Senior Scientific Officer may be expected before reaching the maximum on this scale). Senior Scientific Officer: Qualifications as for Scientific Officer, but minimum age 26 and minimum three years' appropriate postgraduate or other approved experience. Salary £1,342 rising by five annual increments to £1,654, with prospects of promotion to Principal Scientific Officer (£1,716 to £2,418) and above. Assistant Experimental Officer: G.C.E. in five subjects, including two (science and mathematics) at "A" level, or equivalent. Salary £458 at age 18 rising by eight annual increments to £801 at 26 (or on entry over age 26) by five annual increments to £983. Experimental Officer: Qualifications as for Assistant Experimental Officer, minimum age 26. Salary £1,087 rising by five annual increments to £1,336. Prospect of promotion to Senior Experimental Officer (£1,508 to £1,872) and above. Due allowance made for experience when determining starting salary.

Appointments pensionable under the F.S.S.U. Superannuation Scheme, and successful applicants will be considered for establishment within the Scientific Civil Service under existing regulations at an early date. There are opportunities for overseas service, either on short visits or for three-year tours of duty. In the latter case generous overseas allowances are payable.

Application forms and specific inquiries for further information from Director of Operational Science and Research, War Office, Whitehall, S.W.1.

COUNTY OF ESSEX EDUCATION COMMITTEE

MID-ESSEX TECHNICAL COLLEGE AND SCHOOL OF ART
MARKET ROAD, CHELMSFORD
SCIENCE DEPARTMENT

Required September, Lecturer in Physics to teach up to H.N.C., B.Sc. (General) degree and Sandwich Diploma level. Applicants should have a good honours degree with research or industrial experience, and be able to teach a branch of Applied Physics. Salary in accordance with the 1959 Burnham Report: £1,370 by £35 (4) and £40 (1) to £1,550 per annum.

Particulars and application forms from the Clerk to the Governors, to whom completed forms should be returned as soon as possible.

UNIVERSITY OF LEEDS

DEPARTMENT OF BACTERIOLOGY

Applications are invited for appointment as Lecturer or Assistant Lecturer in Bacteriology. Salary on the clinical scale for a Lecturer is £1,350 by £100 to £1,950 (efficiency bar) by £100 to £2,350, or on the scale £1,050 by £50 to £1,400 by £75 to £1,850 (efficiency bar £1,550) if non-medically qualified, and for an Assistant Lecturer on the clinical scale £1,050 by £100 to £1,250, or on the scale £800 by £50 to £950 if non-medically qualified.

Applications (three copies), stating date of birth, qualifications and experience, together with the names of three referees, should reach the Registrar, the University, Leeds, 2 (from whom further particulars may be obtained) not later than May 27, 1961.

AUSTRALIA

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

RESEARCH STAFF

(TWO POSITIONS)

The Organization's Division of Plant Industry, Canberra, A.C.T., invites applications from Honours graduates in Science or Agriculture with some years relevant post-graduate research experience for the under-mentioned vacancies at its **Regional Pastoral Laboratory, Deniliquin, N.S.W.**, where research into the management and utilization of dryland and irrigated pastures is being expanded.

The Laboratory, which has excellent facilities for laboratory and field research including well equipped laboratories, glass-houses, growth room and library and a Field Station of 7,500 acres, including 300 acres under irrigation on which a wide range of experimental work is being conducted. The Laboratory collaborates closely with the staff at the headquarters of the Division in Canberra and the staff of the other Regional laboratories and field stations. The Division has a total professional staff of 140 and is engaged in research in many fields of plant production and biology, including agronomy, ecology, microclimatology, plant nutrition, genetics, physiology and biochemistry.

PASTURE UTILIZATION

(No. 130/103)

The appointee is required to conduct research into the principles of management and utilization of irrigated and dryland pastures with particular emphasis on the integration of summer and winter pasture species for animal production. Current studies of the seasonal productivity of endemic and introduced species will provide a basis for the work involved.

Applicants should have background in ecology or agrostology and experience in animal husbandry is desirable but not essential.

SOIL FERTILITY

(No. 130/100)

The appointee will be required to study the role of organic matter in soil fertility changes under grazed pastures particularly as it affects nutrient availability. Soils with a wide range in texture and nutrient status are being studied for agricultural and pastoral use, with and without irrigation and an important aspect of the work will be the development of methods of assessing soil fertility both in the glass-house and laboratory.

Applicants should have a background in soil chemistry.

Salary: Dependent on qualifications and experience within the ranges: £A.1,510 to £A.2,265 per annum, or £A.2,395 to £A.2,750 per annum.

Salary for women will be £A.180 per annum less than corresponding rates for men.

By mutual arrangement the appointments may be for an indefinite period or for a fixed term of three or five years.

Promotion within C.S.I.R.O. is by merit and may ultimately go beyond the upper limit of the scale within which the original appointment is made.

Fares paid and in the case of a short-term contract return fares will also be paid. Further particulars on conditions, etc., supplied on application to:

Mr. E. J. Drake, Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2,

to whom applications (quoting the relevant Appointment number) should be addressed by June 10, 1961.

UNIVERSITY COLLEGE OF GHANA

Applications are invited for Senior Lectureship in Agricultural Engineering. Salary scale (under review) £G.1,700 by £75 to £G.2,150 per annum, entry point according to qualifications and experience. F.S.S.U. Outfit, family and other allowances. Passages for appointee and family on appointment, leave and normal termination. Part-furnished accommodation at a charge not exceeding 7.5 per cent of salary.

Detailed applications (six copies), naming three referees, by June 20, 1961, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

UNIVERSITY OF SHEFFIELD

Applications are invited for a post of Senior Lecturer in Preventive Medicine and Public Health to begin duties as soon as possible. Candidates should have a sound knowledge and experience of clinical medicine and a particular interest in survey methods and the social aspects of disease. Initial salary according to qualifications and experience on the scale £2,400 by £100 to £3,200, with F.S.S.U. provision and family allowance. A grant towards removal expenses will be made.

Further particulars may be obtained from the Registrar to whom applications (eight copies) should be sent by May 29, 1961.

FOURAH BAY COLLEGE

UNIVERSITY COLLEGE OF SIERRA LEONE

Applications are invited for (A) Senior Lecturer or Lecturer specializing in Applied Mathematics and (B) Lecturer specializing in Pure Mathematics. Salary scales: Senior Lecturer, £1,700 by £75 to £2,150 per annum; Lecturer, £965 by £50 to £1,415; £1,490 by £75 to £1,790 per annum. Negotiations in progress for salary revision. Entry point according to qualifications and experience. F.S.S.U. Outfit and family allowances (maximum £300). Passages for appointee and family on appointment, annual leave and normal termination. Part-furnished accommodation at reasonable rent.

Detailed applications (six copies), naming three referees, by June 10, 1961, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

UNIVERSITY COLLEGE

CORK

LECTURESHIP IN MATHEMATICS

Applications are invited for the vacant Lectureship in Mathematics. Remuneration £1,242 by £54 to £1,620, plus children's allowances. Non-contributory Pension Scheme.

Further particulars may be had from the undersigned. Latest date for receipt of applications—12 noon on May 16, 1961.

JAMES HURLEY,
Secretary.

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

GEOPHYSICISTS

The BUREAU OF MINERAL RESOURCES is seeking the services of Geophysicists for its Geophysical Branch with headquarters at Melbourne, Victoria, Australia.

Successful applicants will be engaged in geophysical prospecting, throughout Australia and its Territories, for mineral deposits (including uranium, oil and coal), by seismic, gravity, electrical and magnetic methods; laboratory investigations, operation of magnetic, seismic and ionospheric observatories and airborne magnetometer and scintillometer surveys.

VACANCIES	SALARY RANGES
Geophysicist Grade 1	£A.1,290 to £A.1,620 (honours graduates commence £A.1,400)
Geophysicist Grade 2	£A.1,620 to £A.1,730
Geophysicist Grade 3	£A.1,730 to £A.1,950

Grade of position and commencing salary will be determined by the applicant's qualifications and experience. Minimum academic qualifications required are:

University degree, preferably with honours, with a major (three-year) pass in Geophysics, Physics, Geology, Mathematics or other appropriate subjects (e.g., Electrical, Radio or Mining Engineering); Physics and Mathematics to second-year standard and Geology to first-year standard desirable for certain positions.

Fares will be provided for successful applicants and dependants, subject to the applicant completing an appropriate Bond of Service. Salary will be paid from date of embarkation.

Application forms and further particulars from:
Official Secretary, Australia House (Ref. 61/2526), Strand, London, W.C.2.

applications close on May 26, 1961.

GHANA CIVIL SERVICE

Applications are invited for vacancies in the grade of Materials Engineer (Development), Public Works Division. Duties: To carry out testing and scientific analysis of road making materials, such as gravel, rock aggregates and bitumen, and to advise as to the best use of the local materials available for road construction and maintenance work and for structures such as bridges and culverts. The duties will include training of subordinate staff. Qualifications: Candidates must (i) possess a degree of a recognized university in engineering, mathematics, physics or chemistry; (ii) must have satisfactorily completed a period of one year's postgraduate full-time training in a recognized Soil Mechanics Research Laboratory; and (iii) must have gained one further year's postgraduate practical experience connected with civil engineering. Salary in range £1,180 to £2,080 per annum. Appointment will be made on limited engagement terms for three tours of duty each of 15 to 18 months. Entry point in the scale depends on qualifications and experience. In addition to salary a tax-free gratuity at the rate of 10 per cent of aggregate salary is payable at the end of each tour of duty, and a tax-free resettlement gratuity of 20 per cent of aggregate salary is payable on the satisfactory completion of contract. Free passages for officer, wife and up to three children under 18 years. Accommodation at low rental and generous leave on full pay. Interest free advance for car, and car maintenance allowance may be granted. Income tax at low local rates.

For application forms, please send postcard to the Director of Recruitment, Ghana High Commission, 248 Tottenham Court Road, London, W.1.

UNIVERSITY COLLEGE OF WALES

ABERYSTWYTH

DEPARTMENT OF BOTANY

Applications are invited for appointment as Research Assistant to undertake work on "The Physiology of Ripening and Senescence in Annual Plants," under a grant from the Agricultural Research Council. Candidates, who should be graduates or prospective graduates, should have a special interest in the field of growth hormones. The person appointed will be eligible to apply for acceptance to work for a higher degree. Salary: £400 (plus superannuation).

Further particulars from the Registrar, to whom applications must be made by May 27.

CHEMIST

TANGANYIKA

Qualifications: Candidates must have a good honours degree in chemistry, or equivalent professional qualification. Specialization in Public Analyst work desirable. R.I.C. Diploma in Applied Chemistry in Branch "E" an advantage.

Duties: General analytical work in toxicology, food and drugs, and water; supervision of assistants.

Terms of Appointment: On contract for a tour of 21 to 27 months in first instance, with gratuity of 25 per cent of emoluments, which are according to experience in the scale £1,221 to £2,448 per annum. Generous education allowances. Outfit allowance. Free family passages. Free medical attention. Furnished quarters at moderate rental if available. Generous leave. Local income tax.

Apply to Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.117/8/037/C1, and stating full name, age, qualifications and experience.

THE SCIENTIFIC CIVIL SERVICE NEEDS men and women for pensionable posts as (a) Experimental Officers and (b) Assistant Experimental Officers in Mathematics, Physics, Meteorology, Chemistry, Metallurgy, Biological Sciences, Engineering, Miscellaneous (Geology, Library and Technical Information Services). Candidates must, on December 31, 1961, be at least 26 and normally under 31 for (a), and at least 18 and normally under 28 for (b). Qualifications should normally include H.S.C., or G.C.E., or equivalent, or H.N.C., a University degree, or a Diploma in Technology. Provisional admission if taking examinations in 1961. London salary scale (a) £1,117 to £1,376; (b) £465 10s. (at 18) to £826 (26 or over) rising to £1,009. Promotion prospects. Further education facilities.—Write, Civil Service Commission, 17 North Audley Street, London, W.1, for application form, quoting **S/94-95/61.**

UNIVERSITY COLLEGE OF GHANA

Applications are invited from suitably qualified candidates for appointment as Chief Technician in the Department of Botany. Candidates must have wide experience in an establishment engaged in research/teaching on plants. The relevant Final City and Guilds Certificate or equivalent or higher qualification would be an advantage. The person appointed will take charge, under the Head of the Department of Botany, of the technical staff, supplies and materials and will be responsible for the efficient running of the botanical laboratories. The appointment is superannuable for Ghanaians on the salary scale £G.1,200 by £G.50 to £G.1,500 plus personal transport allowance, or on a four-year contract for non-Ghanaians. In the latter case the following payments will be made: 15 per cent contract addition, family allowance, outfit allowance and a gratuity of £G.150 per annum. Passages on appointment, leave and completion of contract. Part-furnished accommodation at not more than 7.5 per cent of basic salary.

Applications (six copies), naming three referees, to be sent before May 23, 1961, to the Assistant Registrar (London), University College of Ghana, 15 Gordon Square, London, W.C.1, from whom further particulars may be obtained.

KUMASI COLLEGE OF TECHNOLOGY

SCHOOL OF ARCHITECTURE, TOWN PLANNING AND BUILDING

Applications are invited for appointment to four positions at Lecturer level in the Building Research Group of the above School: (i) Architect; (ii) Architect-Planner or Economist-Planner or Engineer-Planner; (iii) Economist or Sociologist or Anthropologist; (iv) Geographer-Planner or Economic Geographer. Qualifications: Applicants should have a good university degree and/or membership of appropriate professional institutions or equivalent qualifications. A minimum of three years' experience is desirable, but the most important requirement is the ability to collect, correlate and analyse research material obtained in the field, the laboratory and the library, and to follow this up with positive development proposals. The Building Research Group at Kumasi College of Technology is undertaking research into a wide group of building and planning subjects in Ghana. Subjects currently being studied include durability of building materials, new forms of village housing, local and regional planning, economic and sociological factors in building and planning, building design for air conditioning, indoor climate in buildings, etc. The Group also runs a comprehensive Materials Gallery and Information Bureau. The contract salary scale is £1,202 10s. by £65 to £2,112 10s. Pensionable terms are open to Ghanaian applicants. In addition, children's allowances are paid up to a maximum of three, and a gratuity at the end of the contract at the rate of £150 for each year of satisfactory service. The entry point is fixed according to qualifications and experience. This salary scale is, however, under review. The College is fully residential and members of staff are housed in pleasant modern bungalows on the spacious campus; climate and living conditions are good. Annual leave with three free passages in four years is granted to members of staff and their families.

Application forms and full information about the Research Group may be obtained from the Assistant Registrar, Kumasi College of Technology, 29 Tavistock Square, London, W.C.1, who will also be glad to answer any questions.

LONDON COUNTY COUNCIL

SCIENTIFIC BRANCH

SCIENTIFIC OFFICERS

required for County Hall laboratory. Duties involve research, control and development in a wide field.

Salary: £750 to £1,250, according to qualifications and experience.

Promotion opportunities (not depending on vacancy) for suitable officer with necessary ability to Senior Scientific (maximum £1,500). Scientific Officers must hold an honours degree in chemistry or equivalent.

Apply Medical Officer of Health (D1/N/1085/5), County Hall, S.E.1.

COUNTY OF ESSEX EDUCATION COMMITTEE

SOUTH-WEST ESSEX TECHNICAL COLLEGE AND SCHOOL OF ART

FOREST ROAD, WALTHAMSTOW, E.17

Required as soon as possible:

Lecturer to teach Physics to B.Sc. General Degree Standard. Substantial qualifications necessary. An interest in optics or high vacuum techniques would be an advantage. Research facilities, particularly in X-rays, Electronics and Optics, are available, and research is encouraged.

Required in September:

Lecturer in Electronic Chemical Instrumentation. Candidates should hold a degree and be interested in the application of electronics to chemical problems. Teaching experience is essential. This lecturer will be required to teach electronic and chemical instrumentation in the H.N.D., Grad.R.I.C. and H.N.C. Endorsement in Electronic Chemical Instrumentation, and postgraduate and other special courses. Research, for which considerable facilities are available, will be encouraged.

Assistant, Grade B, to teach Chemistry and Mathematics to G.C.E. Advanced Level students. Candidates must hold a degree. Teaching experience is desirable. Research will be encouraged.

Assistant, Grade B, to teach Zoology and Botany to G.C.E. Advanced students. Candidates must hold a degree. Teaching experience is desirable. Ability to teach physiology and experience in one of the fields of applied biology would be an added recommendation.

Assistant, Grade B, to teach Chemistry and Physics to G.C.E. Advanced students. Candidates must hold a degree. Teaching experience and specialization in a branch of either chemistry or physics would be an added recommendation. Research will be encouraged.

Lecturer's salary within scale £1,370 to £1,550 per annum plus £38 or £51 per annum London allowance. Salary for Grade B posts within scale £700 rising to £1,150 per annum plus allowances for approved training and/or qualifications. London Allowance £38 or £51 per annum. Commencing salary will have regard to war/National Service and previous experience.

Apply by letter (no forms) to the Clerk to the Governors, giving details of qualifications, training and experience, together with three testimonials or the names and addresses of three referees.

TROPICAL PESTICIDES RESEARCH INSTITUTE

ARUSHA, TANGANYIKA

Vacancies exist for pesticides specialists:

Chemist: For research into the chemical aspects of the control of tropical pests. Candidates must have a good honours degree in chemistry. Postgraduate research experience, preferably in insecticide analysis, would be an advantage.

Entomologist: To study control of vectors of disease with special reference to acquired resistance under a Senior Entomologist and in cooperation with chemists. Candidates must have a good honours degree in a biological subject.

Biologist: To carry out field and laboratory research on control of snail vectors of Schistosomiasis, in particular the testing and evaluation of new molluscicides, including a co-operative programme with the W.H.O. Candidates must have a good honours degree in a biological subject and experience in research methods of testing pesticides.

Plant Pathologist: To study the plant pathological problems involved in the application of fungicides for the control of plant diseases in the Tropics. Candidates must have a good honours degree in a biological subject and two years postgraduate training or experience, preferably in the study of plant diseases.

All appointments are on contract/gratuity terms for one or two tours of 21-27 months in the first instance. Salaries in scale £1,221 to £2,808. Gratuity 25%. Generous education allowances. Free passages. Furnished accommodation, when available, at low rental. Generous leave.

Apply, stating full name and giving brief particulars of qualifications and experience, to Director of Recruitment, Colonial Office, London, S.W.1. Quote BCD.87/8/01.

SENIOR TECHNICIAN. APPLICATIONS are invited for this position in the Biochemistry Section of a newly-established research organization. Some experience in synthetic organic chemistry is essential. Excellent conditions, opportunity for collaboration in original research, contributory pension scheme. Salary commensurate with qualifications and experience.—Apply to: The Secretary, Twyford Laboratories Ltd., Twyford Abbey Road, London, N.W.10.

PLASTICS TECHNOLOGIST

A Plastics Technologist is required for the Technical Department of an expanding Company which has a modern factory in the West of Scotland.

He will be concerned with the development of manufacturing techniques and the pilot plant production of a new plastic component.

A Degree, or its equivalent, is the preferred qualification and experience of processing plastics, preferably thermo plastics, is essential. Experience in precision injection moulding, compounding or in mould design would be an added advantage.

The position is a responsible one and affords considerable scope for original and interesting work in a field which is a departure from the Company's established range of products.

A starting salary up to £1,500 per annum is offered.

Applications containing brief details of relevant data should be sent to Box No. 965, T. G. Scott and Son, Ltd., 1 Clement's Inn, London, W.C.2.

FEDERAL GOVERNMENT OF NIGERIA

METEOROLOGIST, GRADE II

(AGRICULTURAL METEOROLOGY)

Required by the Meteorological Department in Lagos or Kano to undertake work in agricultural meteorology, and liaison with agricultural specialists, or such other meteorological duties as may be assigned. Candidates should possess a first- or second-class honours degree in Mathematics or Physics, together with at least one year's experience in meteorological work. A knowledge of statistics and of the application of meteorology to agriculture would be an advantage.

Appointment on contract for one tour of 12-18 months in the first instance with prospect of extension. Salary according to qualifications and experience in the scale £1,104 to £2,196 per annum including Inducement Addition, plus gratuity of £100 to £150 per annum for satisfactory service. Outfit allowance of £60 on salaries under £1,741 per annum. Free passages for officer and wife. Children's allowances while separated. Liberal home and local leave on full pay. Income tax at low local rate. Quarters at low rent.

Write for application forms and further particulars within ten days of publication, stating briefly age, qualifications and experience, to the Recruitment Attache, Office of the High Commissioner for Nigeria, Nigeria House, 9 Northumberland Avenue, London, W.C.2, quoting P.4/2.

RED CROSS BLOOD TRANSFUSION SERVICE

QUEENSLAND

BIOCHEMIST

Applications are invited for the position of Biochemist to supervise all chemical procedures and to conduct research in fields related to blood transfusion in consultation with the Director. New Transfusion headquarters are in planning stage and the appointee may be required to advise on the design of the biochemical laboratories. Salary within the limits £A.2,500 to £A.3,500 per annum (actual), to be determined in relation to qualifications and experience. Superannuation is available.

Full details may be obtained from the Director, 109 Adelaide Street, Brisbane.

UNIVERSITY OF NOTTINGHAM

DEPARTMENT OF PHARMACY

Applications are invited for the appointment of an Assistant Lecturer in Pharmacology. Candidates should be graduates in physiology or pharmacology. Salary within scale £800 by £50 to £950, with membership of the Universities Superannuation Scheme and children's allowance.

Conditions of appointment and form of application, which should be returned by May 20, from the Registrar.

REPUBLIC OF THE SUDAN

The Ministry of Education invites applications from suitably qualified candidates for the following posts in the Khartoum Technical Institute:

(1) Assistant Head of Mechanical Engineering Department.

(2) Assistant Head of Civil Engineering and Building Department.

(3) Senior Lecturers in the following subjects: (a) Architecture; (b) Thermodynamics; (c) Electrical Power and Machines; (d) Hydraulics; (e) Theory of Machines; (f) Accountancy.

(4) Lecturers in the following subjects: (a) Electrical Power and Transmission; (b) Strength of Materials; (c) Heat Engines; (d) Theory of Machines; (e) Workshop Technology; (f) Building Construction; (g) Building Science; (h) Building Geometry; (i) Accountancy; (j) Physics (Electricity and Magnetism); (k) Pure and Applied Mathematics; (l) English language; (m) Commercial Law.

(5) Teachers in the Girls' Secretarial School in either: (a) English Typing or (b) Pitman's Shorthand.

Candidates for posts (1) and (2) should possess a University Degree plus appropriate professional qualifications (i.e., A.M.I.C.E. or A.M.I.Mech.E.) and have had teaching experience up to Higher National Certificate level. Candidates for posts (3) and (4) should possess a University Degree or appropriate professional qualifications. In the case of posts (4i), (4k) and (4l) candidates must possess previous teaching experience to the "A" level G.C.E. Candidates for post (5) must possess a recognized Teachers' Diploma in Secretarial Work.

Appointment will be on contract (with bonus) for a period up to five years. Salary scale ranges from £S.1,075 to £S.1,675 per annum for Lecturers and from £S.1,075 to £S.1,975 for Senior Lecturers. Commencing salary in accordance with age, qualifications and experience. In addition to the salary quoted a cost of living allowance, which is reviewed every two months, is payable. This is usually between £S.168 and £S.180 per annum. An initial outfit allowance of £S.50 is payable on appointment. Leave accrues at the rate of seven days per month. A special resettlement gratuity to British Lecturers teaching in English in Secondary Schools and higher institutions of the Ministry of Education will also be paid on satisfactory completion of the period of contract.

Application should be made to the Appointments Section, Sudan Embassy, 3 Cleveland Row, St. James's, London, S.W.1, quoting reference 4/1027.

Closing date May 31, 1961.

AUSTRALIAN NATIONAL UNIVERSITY

CANBERRA

INSTITUTE OF ADVANCED STUDIES

DEPARTMENT OF ASTRONOMY

The University proposes to make three appointments in the Department of Astronomy (Head of Department: Professor B. J. Bok, Mount Stromlo Observatory). Each appointment will be made at one of several levels between those of Senior Fellow and Research Fellow, dependent on the qualifications and experience of the appointee. The salary ranges are: Senior Fellow, £A.3,000 to £A.3,550; Fellow, £A.2,120 to £A.3,000; Senior Research Fellow, £A.2,620 to £A.3,160; Research Fellow, £A.1,625 to £A.2,450. Superannuation is on the F.S.S.U. pattern. Reasonable travel expenses are paid and assistance with housing is provided.

A summary of conditions of appointment and descriptive papers setting out the research programme and facilities of Mount Stromlo Observatory and the Department of Astronomy, A.N.U., are available from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications will be considered immediately after June 1 and October 1, 1961.

CHELSEA COLLEGE OF SCIENCE AND TECHNOLOGY

MANRESA ROAD, LONDON, S.W.3

DEPARTMENT OF CHEMISTRY

Applications are invited for the post of Lecturer from candidates possessing (i) qualifications in Biochemistry, and (ii) research and teaching experience. Teaching duties for the present will be in connection with the College Diploma in Biochemistry. Salary scale: £1,370 by £35 to £1,550, plus London allowance of £38 or £51, according to age.

Particulars and forms of application from the Clerk to the Governors, to whom applications should be submitted not later than May 22, 1961

ROYAL TECHNICAL COLLEGE
SALFORD
DEPARTMENT OF PURE AND APPLIED PHYSICS

Applications are invited for the following posts: Reader in Physics. This post is primarily for the direction and organization of research and the person appointed will be required to initiate and supervise research work in his chosen field. Outstanding research ability is an essential qualification. Salary range: £1,800 rising to £2,100 per annum.

Principal Lecturer in Physics. Candidates should have a good honours degree, together with research and/or industrial experience preferably in the field of nuclear physics. Duties involve lecturing to honours degree standard and to students taking courses in Nuclear Power Technology. Salary range: £1,750 rising to £1,900 per annum.

Senior Lecturer in Physics. Candidates should have a good honours degree, together with research and/or industrial experience. Duties involve lecturing to honours degree standard. The successful candidate will be expected to engage in research. Salary range: £1,550 rising to £1,750 per annum.

The Department organizes courses for the Diploma in Technology in Applied Physics, for London University Degrees and in Nuclear Power Technology, and has an active research school. It is in occupation of newly equipped laboratories.

Further particulars and application forms may be obtained from the Registrar, Royal Technical College, Salford 5, Lancs., to whom completed forms should be returned not later than May 18, 1961.

VICTORIA UNIVERSITY OF WELLINGTON
NEW ZEALAND
LECTURER IN PSYCHOLOGY

Applications are invited for the above-mentioned post. Competence in general and experimental psychology, together with experience and interests in social psychology (qualitative and/or experimental) would be an advantage in a candidate for this position. The salary for a Lecturer will be £1,250 per annum, rising by annual increments of £75 to £1,700. The initial salary will be determined according to the qualifications and experience of the appointee. Approved fares to Wellington will be allowed for the appointee, his wife, and his dependent children. In addition actual removal expenses will be allowed within certain limits.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in New Zealand and London, on June 15, 1961.

ENTOMOLOGIST
BRITISH SOLOMON ISLANDS PROTECTORATE

For entomological work in crop protection with special reference to control of Amblypelta and Brontispa causing damage to coconut palms. Work will also cover insect pests of rice, stored copra, village food crops and cocoa, a new crop in the Protectorate. Candidates must have a university degree in science or agricultural science with specialization in entomology and including some qualifications in plant pathology. Experience in either agriculture or pest control desirable. Appointment on contract/gratuity terms, with emoluments in range £A.1,202 to £A.2,565. Gratuity £A.30 for each completed period of three months service if emoluments under £A.1,440 and £A.45 for each completed period of three months if emoluments over £A.1,440. Up to four free return air passages for officer, wife, and children. Furnished accommodation normally available on low rental. Generous leave.

Apply, stating full name and giving brief particulars of qualifications and experience, to Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/45/04.

UNIVERSITY OF SHEFFIELD

Applications are invited for a newly established second Chair of Physics tenable from October 1, 1961, or a later date to be arranged. Candidates may be either Theoretical or Experimental Physicists. Salary not less than £2,900, with F.S.S.U. provision and family allowance. A grant towards removal expenses will be made.

Further particulars should be obtained from the Registrar, to whom applications (20 copies—one only from overseas candidates) should be sent by June 10, 1961.

LEVINGTON RESEARCH STATION
DEPARTMENT OF SOIL SCIENCE

FISONS FERTILIZERS LIMITED invite applications for the interesting and responsible appointment of Agricultural Adviser in the provinces on the staff of Levington Research Station.

Applicants should be graduates in Agriculture and be well informed on matters of specialist agricultural advice. Experience of field experimentation will be advantageous as the appointment is concerned mainly with this subject.

An Agricultural Adviser resident in a provincial location is provided with a car and has a Crop Recorder attached to him for assisting with field experiments.

This is a senior appointment and the salary offered will depend upon qualifications and experience. There are contributory pension and widow's pension schemes.

Applications, giving qualifications and experience, should be made to the Personnel Manager (LN10), Fisons Fertilizers Limited, Harvest House, Felixstowe.

THE ROYAL COLLEGE OF SCIENCE AND TECHNOLOGY, GLASGOW
SENIOR LECTURESHIP IN INORGANIC CHEMISTRY

Applications are invited for the above post in the Department of Chemistry. The appointment will date from September 1, 1961, and will be on the salary scale £1,975 by £75 to £2,275 with family allowance and F.S.S.U. benefits.

Applications should be lodged with the Secretary of the College, George Street, Glasgow, C.1 (from whom further details may be obtained), not later than May 31, 1961.

UNIVERSITY OF SYDNEY
LECTURESHIP/SENIOR LECTURESHIP IN GEOLOGY

Applications are invited for the above-mentioned position. Applicants should be especially interested and qualified in mineralogy and crystallography and preferably have had experience in X-ray techniques. The salary for a Lecturer is within the range £A.1,730 by £A.105 to £A.2,435 per annum, for a Senior Lecturer £A.2,550 by £A.95 to £A.3,000 per annum, plus cost of living adjustments (at present £A.36 per annum) and is subject to deductions under the State Superannuation Act. The commencing salary will be fixed according to qualifications and experience of the successful applicant. Under the Staff Members' Housing Scheme, in cases approved by the University and its bankers, married men may be assisted by loans to purchase a house.

Further particulars may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close in Australia and London on June 9, 1961.

UNIVERSITY OF LEEDS
DEPARTMENT OF INORGANIC AND STRUCTURAL CHEMISTRY

Applications are invited for appointment as Lecturer or Assistant Lecturer in the Department of Inorganic and Structural Chemistry at a salary on the scale £1,050 by £50 to £1,400 by £75 to £1,850 (efficiency bar at £1,550) a year for a Lecturer or within the range £800 to £950 a year for an Assistant Lecturer, according to age, qualifications and experience.

Applications (three copies), stating date of birth, qualifications and experience, together with the names of three referees, should reach the Registrar, the University, Leeds, 2 (from whom further particulars may be obtained), not later than May 12, 1961.

UNIVERSITY OF QUEENSLAND
SENIOR LECTURER IN PHYSICS

Applications are invited for the above-mentioned position. There are two positions available, one at Brisbane and one at University College, Townsville. Applicants must possess a Ph.D. degree in physics from a recognized university or academic and research qualifications equivalent thereto. Applicants with previous university teaching experience will receive preference, especially for the position at Townsville. Salary: £A.2,520 by £A.70 to £A.2,870 per annum. The successful applicant will enjoy the privileges of superannuation, study leave, travel grants and other benefits available to the academic staff.

Further particulars and application forms are obtainable from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Australia and London, on May 31, 1961.

UNIVERSITY OF ST. ANDREWS

Applications are invited for a Lectureship in Midwifery in the Department of Midwifery and Gynaecology, Queen's College, Dundee. Medically qualified applicants should hold the M.R.C.O.G. or have completed at least one year as a registrar. A scientist trained in physiology would be seriously considered. Salary scale, either clinical grade: £1,050 by £100 to £2,350 (efficiency bar £1,550); or non-medical science scale: £1,050 by £50 to £1,400 by £75 to £1,850 (efficiency bar £1,400). F.S.S.U., family allowance, grant towards furniture removal expenses.

Applications (six copies), containing the names of three referees, to the undernoted not later than June 3, 1961.

PATRICK CUMMING,
Joint Clerk to the University Court.

Queen's College,
Dundee.

UNITED NEWCASTLE UPON TYNE HOSPITALS

Applications are invited for the appointment of Research Biochemist to participate in a project investigating the effect of age on oestrogen and progesterone excretion in pregnancy. The work will be carried out in the Biochemistry Laboratory of the Royal Victoria Infirmary. This post offers an excellent opportunity for persons aspiring to higher qualifications and the successful applicant would be recommended for an honorary appointment with the university as Research Associate so that he can apply for permission to read for a Ph.D. degree. The salary will be within the range of £645 per annum rising to a maximum of £1,035 per annum, the commencing salary will depend on experience and qualifications.

Applications, giving full particulars and the names and addresses of three referees, should be sent to the House Governor and Secretary, Royal Victoria Infirmary, Newcastle upon Tyne 1, within two weeks of the appearance of this advertisement.

MOREDUN INSTITUTE
(Independent State-aided Agricultural Research Institute)

Applications invited for appointment as Head of Department of Parasitology (Helminthology). Major division of Institute—well equipped—with good facilities for experimental work with farm animals. Salary in range: Principal Scientific Officer (£1,716 to £2,418); Senior Principal Scientific Officer (£2,650 to £3,000) depending on qualifications and experience. Superannuation F.S.S.U.

Apply in writing, giving names of two referees, to the Secretary, Animal Diseases Research Association, Moredun Institute, Gilmerton, Edinburgh 9.

MINISTRY OF AVIATION, HAREFIELD, Middlesex. Technician required for technical direction of staff engaged on supervision of distribution of petroleum products; inspection of contractors' plant and equipment used for storage and distribution of petroleum products, and inspection of other non-metallic materials. Qualifications H.N.C., or equivalent. Recognized engineering apprenticeship or equivalent training. Knowledge and experience of testing and inspection of petroleum products, their storage and distribution. Knowledge of other non-metallic materials, e.g., plastics, rubbers, plywood and adhesives an advantage. Good prospects for promotion and pension. Salary £1,173 to £1,438.—Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting F.207/1A. Closing date May 29, 1961.

MANCHESTER COLLEGE OF SCIENCE AND TECHNOLOGY

(Faculty of Technology in the University of Manchester)

Appointment of

LECTURER OR ASSISTANT LECTURER IN PHYSICS

Applications are invited for a Lectureship or an Assistant Lectureship in Physics in the College with corresponding title and status in the University of Manchester. The successful candidate will be required to take part in the teaching of the department which is almost entirely concerned with internal degrees of the Faculty in Physics and other subjects. He will also be allowed ample time for research under the general direction of Professor H. Lipson, the main subjects at present being X-ray diffraction, physical optics, acoustics and luminescence. Salary: Lecturer, £1,050 by £50 to £1,400 by £75 to £1,850; Assistant Lecturer, £800 by £50 to £950. Commencing salary in each case according to qualifications and experience. Superannuation under the F.S.S.U. Family allowances.

Conditions of appointment and forms of application may be obtained from the Registrar, The Manchester College of Science and Technology, Manchester, 1, to whom applications must be returned by Saturday, May 27, 1961.

UNIVERSITY OF THE WITWATERSRAND

JOHANNESBURG

STAFF VACANCIES

Applications are invited for the following vacant appointments: Otto Beit Chair of Physiology. Senior Lecturers in Department of Physiology. Lecturer in Department of Pathology and Microbiology. Senior Lecturer and Lecturer in Department of Mathematics (permanent or temporary). Senior Lecturer and Lecturer in Physical Chemistry. Salary scales: Chair, R.5,000 by R.200 to R.5,600 (£2,500 by £100 to £2,800); Senior Lecturer, R.3,180 by R.120 to R.4,140 (£1,590 by £60 to £2,070); Lecturer, R.2,940 by R.120 to R.3,540 (£1,470 by £60 to £1,770).

For full details of conditions of appointment and closing dates for applications apply immediately to the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1.

HASTINGS EDUCATION COMMITTEE

HASTINGS COLLEGE OF FURTHER EDUCATION

ARCHERY ROAD, ST. LEONARDS-ON-SEA

The following full-time teaching staff are required for September 1, 1961: 1. Lecturer in Electrical Engineering required to teach Electronics and Electrical Technology to H.N.C. level. Ability to teach some Physics would be an advantage. A Degree or corporate membership of the I.E.E. or (Brit.I.R.E. essential. Salary £1,370 to £1,550. 2. Assistant (Grade B) to teach Chemistry up to "A" level G.C.E. Ability to assist with another Science, or Mathematics an advantage. Degree, H.N.C. or A.R.I.C. essential. Salary £700 to £1,150, plus Graduate and equivalent allowances. Commencing salaries dependent on qualifications and approved industrial and/or teaching experience.

Further particulars and forms of application (to be returned within 14 days) obtainable from the Principal.

BRISTOL COLLEGE OF SCIENCE AND TECHNOLOGY

ASHLEY DOWN, BRISTOL, 7

DEPARTMENT OF PHYSICS

The Governors invite applications for the following posts: (1) Lecturer; (2) Assistant, Grade B. Applicants should possess an honours degree in physics, and have had research or industrial experience in some aspect of Applied Physics which, in the case of one post should preferably include Electronics. Teaching experience desirable. Burnham Technical Scale salaries: Lecturer, within range £1,370 to £1,550 per annum; Assistant, Grade B, within range £790 to £1,435 per annum.

Details and application forms from the Registrar. When applying, please quote reference CST 61/14.

BIOCHEMIST (PROBATIONARY OR BASIC Grade) required to assist in biochemical and biological assay work in connection with endocrinological aspects of cancer research. Whitley Council scales of pay.—Applications, with details of age, qualifications and experience, and the name of a referee, to the House Governor, the Royal Marsden Hospital, Fulham Road, London, S.W.3.

THE PATENT OFFICE

OFFERS SCIENTISTS A CAREER WITH AN ASSURED FUTURE

SALARY. Starting salary within the scale £793 to £1,719 according to experience, with advances in the scale to £941 after two years and to £1,324 after 3 to 5 years, for those starting below these points. One promotion only (prospects excellent) raises maximum to £2,715. Further prospects up to £4,415.

QUALIFICATIONS. Age 21 to 35 and Degree or Diploma of Technology with first- or second-class honours in physics, chemistry, engineering or mathematics, or equivalent professional qualification, e.g., A.Inst.P., A.R.I.C., or corporate membership of I.C.E., I.Mech.E. or I.E.E.

INTEREST. The examination of patent specifications will maintain your knowledge of science and technology completely up-to-date and will give you inside knowledge of new manufactures well ahead of the public at large.

CONDITIONS. Location, London. Five-day week. Annual leave 4½ rising to 6 weeks with considerable freedom as to when it is utilized. Posts are permanent and pensionable (non-contributory).

Write or telephone for further information or for a visit to see the work. *The Superintending Examiner (B. Staff), The Patent Office, 25 Southampton Buildings, London, W.C.2. Holborn 8721, Ext. 324.*

UNIVERSITY OF LEEDS

DEPARTMENT OF ELECTRICAL ENGINEERING

Applications are invited for appointment to Lectureships in the Department of Electrical Engineering. The requirements fall into two categories: (1) Honours degree in physics, together with experience in the electrical engineering industry. (2) Honours degree in electrical engineering, together with industrial or other experience in one of the following fields: electric power engineering, electrical machines, or electrical measurements. Salary on the scale £1,050 by £50 to £1,400 by £75 to £1,850 (efficiency bar at £1,550), according to age, qualifications and experience.

Applications (three copies), together with the names of three referees, should reach the Registrar, The University, Leeds, 2 (from whom further particulars may be obtained), not later than May 22, 1961.

UNIVERSITY OF LEEDS

DEPARTMENT OF GEOLOGY

Applications are invited for appointment as Lecturer or Assistant Lecturer in the Department of Geology at a salary on the scale £1,050 by £50 to £1,400 by £75 to £1,850 (efficiency bar at £1,550) for a Lecturer, or within the range £800 to £950 for an Assistant Lecturer, according to age, qualifications and experience. Preference may be given to candidates having special interests or qualifications in igneous and metamorphic petrology.

Applications (three copies), stating date of birth, qualifications and experience, together with the names of three referees, should reach the Registrar, The University, Leeds, 2 (from whom further particulars may be obtained), not later than May 12, 1961.

UNIVERSITY OF MANCHESTER

Applications are invited for a Research Post (under the Agricultural Research Council) in the Department of Botany. Candidates should be graduates with qualifications in botany or biochemistry; the successful applicant will be required to work on the biochemistry of senescence in plant tissues. Facilities for studying for a higher degree are available. Salary £400 per annum.

Applications should be sent not later than May 13, 1961, to Dr. E. W. Simon, Department of Botany, the University, Manchester, 13.

NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING

(UNIVERSITY OF READING)

The Chemistry Department has two vacancies:—Ref. 61/14: Experimental Officer required to take part in research on ruminant nutrition and milk composition, and to be responsible for analytical work, including gas chromatography and other modern techniques. Candidates should have suitable analytical experience. Ref. 61/15: Assistant Experimental Officer required to assist in studies of mineral metabolism in cattle. Candidates should be interested in both chemical analysis and working with animals. Candidates should be graduates or hold A.R.I.C., H.N.C., or an equivalent qualification, or for the Assistant Experimental Officer post G.C.E. "A" level or an equivalent if under 22. Salary scales: 61/14, £1,057 to £1,336; 61/15, £450 10s. to £983. A contributory pension scheme is in operation.

Application forms from the Secretary, N.I.R.D., Shinfield, Reading, quoting appropriate ref. no.

CITY OF PORTSMOUTH COLLEGE OF TECHNOLOGY

DEPARTMENT OF MATHEMATICS AND PHYSICS

Applications are invited for the posts of (a) Senior Lecturer in Theoretical Physics; (b) Lecturer in Mathematics. Salary scales (a) £1,550 to £1,750; (b) £1,370 to £1,550.

Further particulars and application forms, to be returned by May 20, 1961, may be obtained from the Registrar, College of Technology, Portsmouth.

UNIVERSITY COLLEGE OF SWANSEA

Applications are invited for a Lectureship in Chemical Engineering. Salary on the scale £1,050 to £1,850 per annum. Membership of F.S.S.U. and children's allowance scheme.

Further particulars may be obtained from the Registrar, University College, Singleton Park, Swansea, to whom applications (six copies) must be sent by May 20, 1961.

ROYAL UNIVERSITY OF MALTA

Applications are invited for (a) Lectureships or (b) Assistant Lectureships in: Chemistry; Mathematics. Salary scales: (a) £1,300 per annum, (b) £800 by £50 to £950 per annum (including overseas allowance). F.S.S.U. Passages provided for appointee, wife and children under 12 years on appointment and termination. Applications for Assistant Lectureship will be considered from students in their final year of study. Duties to be assumed on October 1, 1961.

Detailed applications (six copies), naming three referees, by June 10, 1961, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

HILL FARMING RESEARCH ORGANIZATION

Applications are invited from research workers with specialized knowledge and experience in animal research for appointment in the grade of Senior Principal Scientific Officer. The salary scale attaching to the appointment will be £2,650 by £100 to £2,750 by £125 to £3,000 per annum, and the superannuation arrangements will be those afforded by the F.S.S.U.

Further particulars may be obtained from the Secretary of the Organization at 48 Palmerston Place, Edinburgh, 12, to whom applications, accompanied by the names and addresses of three referees, must be submitted not later than May 31, 1961.

NOTTINGHAM AND DISTRICT TECHNICAL COLLEGE

BURTON STREET, NOTTINGHAM

Principal: D. A. R. Clark, M.Sc.(Tech.), M.I.Mech.E.

Applications are invited for the post of Lecturer in Physical Chemistry. The work includes the teaching of the subject to the standard of Grad.R.I.C. and B.Sc. Research and/or industrial experience would be an advantage. Salary in accordance with the Burnham Technical Scale: £1,370 by £35 to £1,550 per annum. A salary above the minimum will be paid in approved cases. Research encouraged. Facilities and equipment available.

Further particulars and form of application may be obtained from the Principal, to whom completed forms should be returned not later than May 19, 1961.

NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY

LONDON, E.C.1

MATHEMATICS DEPARTMENT

Applications are invited from graduates for appointment as Research Assistant to work either in Computing, Mathematics or Statistics. The successful applicant will be encouraged to submit a thesis for a higher degree. The duties may include a limited amount of teaching. Remuneration will amount to approximately £500 per annum.

Further particulars and forms of application are obtainable from the Secretary, Northampton College of Advanced Technology, St. John Street, London, E.C.1.

UNIVERSITY OF ABERDEEN

RESEARCH FELLOWSHIP

Applications invited for a Postdoctoral Fellowship (Senior or Junior) for research on the Immunology of the Pituitary Gonadotrophic Hormones to be carried out in the Agricultural Biochemistry Division of the Department of Biological Chemistry. Previous experience of immunological methods desirable but not essential. The appointment would be for one year in the first instance. The value of this Fellowship will be within the range £800 to £1,050 per annum with F.S.S.U.

Applications should be sent to the Secretary, the University, Aberdeen, from whom further particulars may be obtained.

MIDLAND CENTRE FOR NEUROSURGERY

An honours degree science graduate is required to take charge of the electron microscopy section of the Department of Pathology. Salary £730 by £30 (3) to £820 by £35 (3) to £925. The post is at present financed by a research grant and is renewable yearly. The electron microscope is mainly used in the study of nervous tissue and muscle, and the post would be of interest to graduates from the basic or biological sciences wishing to obtain experience in biophysics. The laboratory may be visited on application to the pathologist, Dr. A. L. Woolf.

Applications, accompanied by the names and addresses of three referees, should be submitted to the Group Secretary, Mr. J. O. Robins, West Bromwich and District General Hospital, West Bromwich, by May 20, 1961.

UNIVERSITY OF SHEFFIELD

Applications are invited for a post of Lecturer or Assistant Lecturer in Pure Mathematics to begin duties on October 1, 1961. Initial salary according to qualifications and experience on the scales: Lecturer, £1,050 by £50 to £1,400 by £75 to £1,850; Assistant Lecturer, £800 by £50 to £950, with F.S.S.U. provision and family allowance. A grant towards removal expenses will be made.

Further particulars may be obtained from the Registrar to whom applications (four copies) should be sent by May 27, 1961.

UNIVERSITY OF QUEENSLAND

SENIOR LECTURER IN PHYSICAL CHEMISTRY

Applications are invited for the above-mentioned position. Applicants should have a higher degree, preferably a doctorate with special qualifications in some branch of physical chemistry. University teaching and research experience is essential. Salary: £A.2,520 by £A.70 to £A.2,870 per annum. The successful applicant will enjoy the privileges of superannuation, study leave, travel grants and other benefits available to the academic staff.

Further particulars and application forms are obtainable from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Australia and London, on June 10, 1961.

UNIVERSITY OF BIRMINGHAM

SENIOR LECTURESHIP IN THE DEPARTMENT OF PHYSICS

Applications are invited for a Senior Lectureship in the Department of Physics. The person appointed will be expected to make substantial contributions to the research programme in high-energy nuclear physics as well as to participate in teaching. This is a new post tenable from October 1, 1961, and the initial salary will be at an appropriate point on the scale: £1,650 by £75 to £2,325 per annum, with F.S.S.U. and family allowance benefits.

Applications (three copies) should be sent by May 24, 1961, to the Assistant Registrar (Science), the University, Edgbaston, Birmingham, 15, from whom further particulars of the appointment and of the research programme may be obtained.

MACAULAY INSTITUTE OF SOIL RESEARCH

DEPARTMENT OF PLANT PHYSIOLOGY

Applications are invited for the appointment of a Plant Physiologist (male) to work on general problems of growth and mineral nutrition. Candidates should possess a first- or second-class honours degree in botany with chemistry as subsidiary subject. Applications from Ph.D. students graduating this year will be considered. The appointment will be made in the Scientific Officer grade, starting salary within the range £738 to £1,222 per annum, according to age, qualifications and experience. Superannuation Scheme.

Forms of application may be obtained from the Secretary, the Macaulay Institute for Soil Research, Craigiebuckler, Aberdeen, to whom they should be returned before June 10, 1961.

QUEEN'S UNIVERSITY OF BELFAST

The Senate of the Queen's University of Belfast invites applications for an Assistant Lectureship in Applied Mathematics from October 1, 1961, or such other date as may be arranged. Applicants should have special qualifications in Experimental Physics, Aeronomy or Astronomy. The salary scale is £800 by £50 to £950, plus F.S.S.U. Initial placing on this scale will depend on experience and qualifications. Applications should be received by May 20, 1961.

Further particulars may be obtained from G. R. Cowie, M.A., LL.B., J.P., Secretary to the University.

IMPERIAL CANCER RESEARCH FUND

Junior Biochemist required for new virus project. Experience in tracer techniques an advantage. Salary according to age, qualifications and experience.

Applications to Dr. R. J. C. Harris, Imperial Cancer Research Fund, Mill Hill, London, N.W.7.

UNIVERSITY OF BELFAST

The Senate of the Queen's University of Belfast invites applications for a Lectureship in Applied Mathematics from October 1, 1961. Salary range £1,050 to £1,850 p'us contributory pension rights under the F.S.S.U. Initial placing on the salary scale will depend on qualifications and experience. Applications should be received by May 17, 1961. Further particulars may be obtained from G. R. Cowie, M.A., LL.B., J.P., Secretary, The Queen's University of Belfast, Belfast 7, Northern Ireland.

UNIVERSITY OF ABERDEEN. APPLICATIONS are invited from suitably qualified persons to operate (and maintain) an electron microscope to be installed shortly for scientific and medical departments within the University. Experience of operation and maintenance of an electron microscope essential and knowledge of electronics and high vacuum technique an advantage. Salary in range £690 to £1,015 per annum, with placing according to qualifications and experience.—Applications, with names of two referees, to Secretary to the University, Marischal College, Aberdeen, by May 15, 1961.

THE MEDICAL COLLEGE OF ST. Bartholomew's Hospital, West Smithfield, E.C.1. Applications are invited for the post of Senior Lecturer in Neuropathology tenable as from October 1, 1961. The salary will be on the scale £2,000 by £100 to £2,400, together with children's allowance and membership of the F.S.S.U. Candidates should have a specialized knowledge of neuropathological technique and will be required to devote time to research as well as to undertake routine duties.—Forms of application, which must be returned not later than June 3, may be obtained from the Secretary of the Medical College.

A RESEARCH PHYSICIST (ELECTRONIC) to develop in-vivo localization techniques. Salary £965 or £1,000 per annum.—Details from the Director, Physics Department, Hammersmith Hospital, Du Cane Road, London, W.12.

THE MURPHY CHEMICAL CO. LTD., Wheathampstead, St. Albans, Herts, has a vacancy for a qualified and experienced Research Biologist to take charge of a team of research workers working on the development of new insecticides and fungicides. Applicants must have extensive knowledge of the use of crop protection materials in the field as necessary background to the evaluation of new chemicals at laboratory level. Preferred age 30 to 40 years. An attractive salary will be offered to the successful applicant. Pension scheme.—Applications, giving full details, should be addressed to the Personnel Officer.

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Further details from Dr. Gaydon, Chemical Engineering Department, Imperial College, London, S.W.7.

UNIVERSITY OF READING

Applications are invited for a post of Lecturer in the Department of Horticulture to teach biological aspects of horticultural crop protection. Preference will be given to a candidate with research experience in plant-insect relations or a related field.

Further particulars may be obtained from the Registrar (Room 22, O.R.B.), the University, Reading, by whom applications should be received not later than May 31, 1961.

UNIVERSITY OF SOUTHAMPTON

A vacancy exists in the Department of Aeronautics and Astronautics for a Research Fellowship or Assistantship in the field of hypersonic gas dynamics. Applicants should have a good honours degree in mathematics or engineering. Experience in programming for a digital computer will be an advantage. The salary will be in the range £700 to £1,100 according to age and experience.

Further details may be obtained from the Secretary and Registrar.

UNIVERSITY OF BELFAST

The Senate of the Queen's University of Belfast invites applications for an Assistant Lectureship in Zoology from October 1, 1961. An interest in marine zoology is desirable. The salary scale is £800 by £50 to £950, plus F.S.S.U. Initial placing on this scale will depend on experience and qualifications. Applications should be received by May 20, 1961.

Further particulars may be obtained from G. R. Cowie, M.A., LL.B., J.P., Secretary to the University.

UNIVERSITY OF WALES

A number of Fellowships, each of the annual value of £650 with the payment of approved fees and tenable for two years, will be awarded in 1961 to graduates of the University of Wales. Candidates for the Fellowships should send their applications to the Registrar, University Registry, Cathays Park, Cardiff, not later than June 1, 1961.

Further information may be obtained from the Registrar.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

Research Assistantsh p available to suitable graduate (preferably post-doctoral) for research in solid state and surface chemistry for two years from September/October, 1961. Salary £850 per annum, plus family allowance if applicable and F.S.S.U. benefits.

Applications, giving age, qualifications and experience, to Professor F. C. Tompkins, Chemistry Department, Imperial College, London, S.W.7.

UNIVERSITY OF OTTAWA

OTTAWA, ONTARIO, CANADA

Assistant Professor in Pharmacology required, Ph.D. or M.B. Salary $6,000 to $8,500, according to qualifications and experience.

Applications to Professor M. F. Murnaghan at the above address.

INSTITUTE OF CANCER RESEARCH: Royal Cancer Hospital. Research Assistant required to assist in work on tissue transplantation at Pollards Wood Research Station, Chalfont St. Giles, Bucks. Candidates preferred with G.C.E. "A" level or higher qualification in biochemistry or biology. Salary on M.R.C. scales for Technical Officers according to age, qualifications and previous experience.—Apply, with names of two referees, to the Secretary, 33 Sumner Place, S.W.7, quoting ref. 301/B/61.

JOHN INNES INSTITUTE REQUIRE AN assistant with chemical background to help in biochemical investigations in potatoes in the Department of Potato Genetics. The appointment will be in the Assistant Experimental Officer grade, and a pass degree or equivalent qualification is required. Salary will be in the range £550 to £800 per annum, according to age and experience. Superannuation.—Applications, with the names of two referees, should be addressed to the Secretary, Bayfordbury, Hertford, not later than June 5, 1961.

UNIVERSITY OF LIVERPOOL

Applications are invited for the post of Lecturer in the Department of Metallurgy. The initial salary will be within the range £1,050 to £1,350 per annum, according to age, qualifications and experience.

Applications, stating age, academic qualifications and experience, together with the names of three referees, should be received not later than May 15, 1961, by the Registrar, from whom further particulars of the conditions of appointment may be obtained, quoting ref. CV/N.

UNIVERSITY OF BIRMINGHAM

DEPARTMENT OF CIVIL ENGINEERING

Applications are invited for the post of Senior Research Associate for research on reinforced plaster model structures in the Department of Civil Engineering. Candidates should possess a degree, or equivalent qualification in a scientific subject and must be used to handling and developing testing apparatus and to recording and reducing observations. Previous engineering experience is not essential. Salary at an appropriate point in the range £875 to £1,000. The appointment will be for two years in the first instance.

Applications should be sent to Dr. G. Brock, Department of Civil Engineering, the University, Edgbaston, Birmingham, 15.

SCOTTISH MARINE BIOLOGICAL ASSOCIATION

Applications are invited from Class I or IIa graduates for the post of Zoologist at the Marine Station, Millport, in the grade of *Scientific Officer* or *Senior Scientific Officer*, according to qualifications, age and research experience. Wide choice will be given in the field of work, with preference to those lines of fundamental research which need the sea-going and other facilities of a marine laboratory.

Application forms and particulars from: The Director, Marine Station, Millport, Isle of Cumbrae, Scotland.

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required by East African Trypanosomiasis Research Organization, East Africa High Commission, on contract for one tour of 24-27 months in first instance with gratuity at rate of 25% of total salary drawn. Commencing salary according to experience in scale (including inducement pay) £1,056, rising to £1,956 a year. Outfit allowance £30. Free passages. Liberal leave on full salary. Generous education allowances. Quarters provided at nominal rental. Candidates should have A.I.M.L.T. or adequate experience in a clinical pathology laboratory, experience in clinical chemistry an advantage. Women candidates must be single.

Apply to Crown Agents, 4 Millbank, London, S.W.1, for application form and further particulars, stating age, name, brief details of qualifications and experience, and quoting reference M3C/52927/NF.

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Applications are invited for the above studentships, one of which is available now, others as from September, 1961, to be held in the Department of Pure and Applied Chemistry. Applicants should hold or anticipate having a good honours degree in Chemistry, Grad.R.I.C., or a Dip.Tech. in chemistry. The projects are for the study of products from the low temperature carbonization of coal and will be suitable for studies leading to a postgraduate degree or equivalent. Each studentship will carry a yearly stipend of £500.

Applications, giving full details, including the names of referees, should be sent to the Reader in Industrial Chemistry as soon as possible.

THE ROYAL SOCIETY

SCIENTIFIC PUBLICATIONS GRANT

Applications for grants from the first allotment of the Government Grant for Scientific Publications for the year 1961, should be made as soon as possible. No application can be considered which is received later than June 15, 1961. This grant is provided for the assistance of scientific publications in the United Kingdom, particularly but not exclusively those of scientific societies and institutions of a national character. A small part of the grant is available for the assistance of the libraries of scientific societies. Applications are receivable only from societies and institutions in the United Kingdom and individuals of British nationality.

Forms of application may be obtained from the Assistant Secretary, The Royal Society, Burlington House, London, W.1.

UNIVERSITY OF CAMBRIDGE

Applications are invited for two Research Grants tenable at the Department of Colloid Science from October 1, 1961, for theoretical and experimental work on particle interaction in colloidal systems. Successful candidates would be expected to become registered research students and to study for higher degrees in the University.

Further details from the Secretary, Department of Colloid Science, Free School Lane, Cambridge.

IMPERIAL COLLEGE: BURSARY OF £425 out of which fees must be paid, provided by a group of Optical Instrument Firms, available for one year for the postgraduate course in Technical Optics.—Further particulars from the Registrar, Imperial College, London, S.W.7. Closing date June 1, 1961.

LECTURES AND COURSES

UNIVERSITY OF LONDON

ROYAL FREE HOSPITAL SCHOOL OF MEDICINE

M.SC. DEGREE IN RADIATION BIOLOGY AND RADIATION PHYSICS

A course of lectures and laboratory work for this degree will commence in October, 1961. The course generally requires full-time attendance for two academic years and candidates for entry must have an honours degree in a physical or biological science or a medical qualification. The first year of studies is introductory to the special field of study in the second year of the interaction of ionizing radiation with living systems. This course is intended as a training for those wishing to undertake fundamental research in this field and may also be considered as a training for those wishing ultimately to obtain higher managerial posts in the field of radiological health and safety.

The fee for the course is 30 guineas per term and further details may be obtained from, and applications for entry should be made to, the Registrar, Royal Free Hospital School of Medicine, 8 Hunter Street, London, W.C.1.

IMPERIAL COLLEGE

LONDON, S.W.7

A course of lectures on "Toxic Hazards," arranged by Dr. J. H. Burgoyne and Dr. V. D. Long, will be given in the Department of Chemical Engineering and Chemical Technology during the week commencing Monday, June 19, 1961.

Further details from the Registrar.

UNIVERSITY OF CAMBRIDGE

SUMMER SCHOOL IN PHYSICAL CHEMISTRY

AUGUST 12 to 19, 1961

The 1961 Summer School will be devoted to general aspects of Fast Reactions in liquid and gaseous phases.

Over 100 scientists from many countries have already applied to attend this course, and further applications will be warmly welcomed by the Secretary of the Summer School, University Physical Chemistry Laboratory, Lensfield, Cambridge.

UNIVERSITY OF LONDON: A COURSE OF three lectures entitled (1) "Micro X-ray Analysis Applied to Biology and Medicine"; (2) "Bone as a Problem in Molecular Biology"; (3) "Dose-damage Relationship for Internal Contamination with Radioisotopes" will be delivered by Professor A. Engström (Stockholm) at 5.30 p.m. on May 15, 16 and 17, at King's College, Strand, W.C.2. Admission free, without ticket.—James Henderson, Academic Registrar.

UNIVERSITY OF LONDON: A COURSE OF two lectures entitled "Studies on Free Radical Reaction Mechanisms" will be delivered by Professor P. D. Bartlett (Harvard) at 5.30 p.m. on May 10 and 11 at King's College, Strand, W.C.2. Admission free, without ticket.—James Henderson, Academic Registrar.

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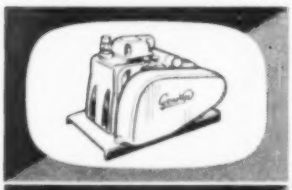

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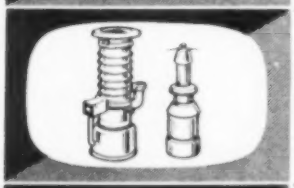

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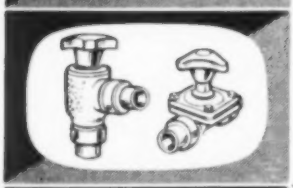

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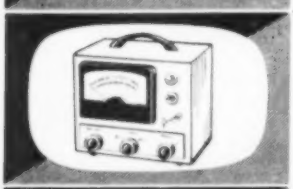

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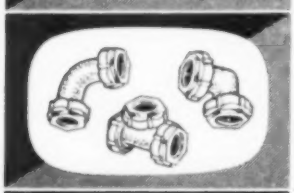

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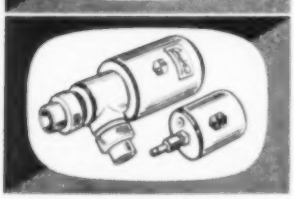

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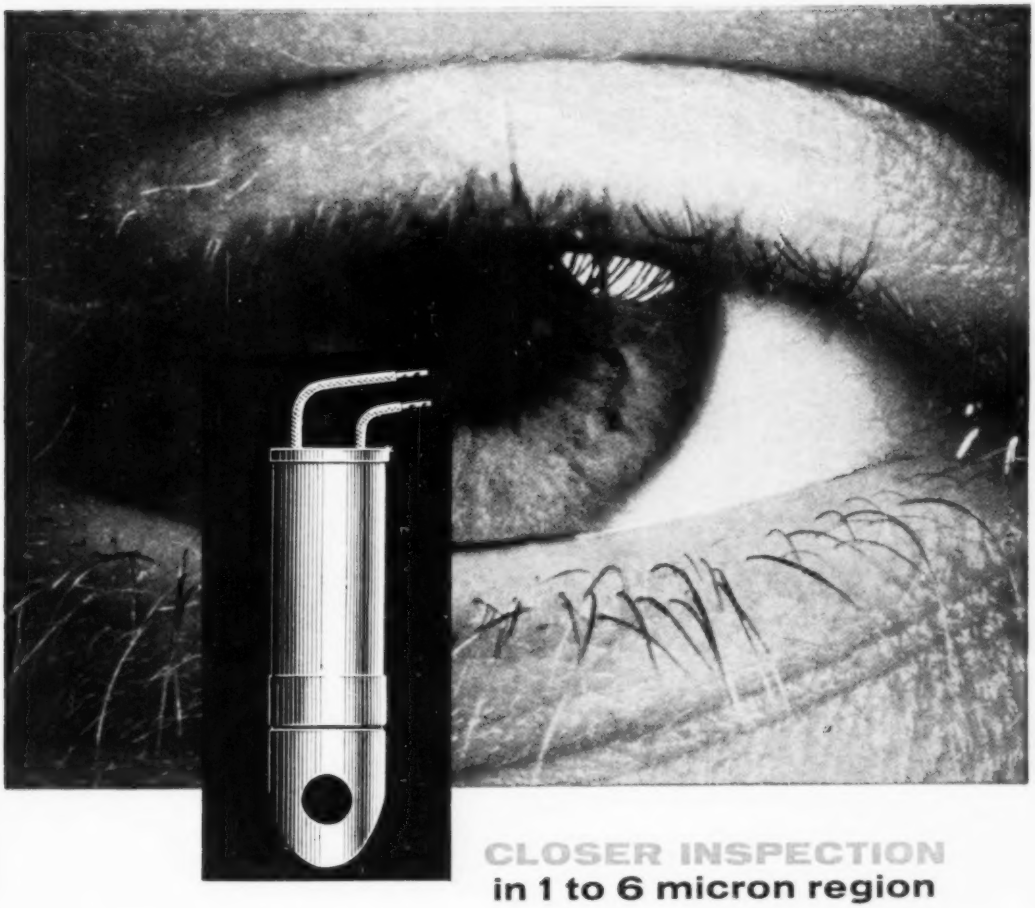

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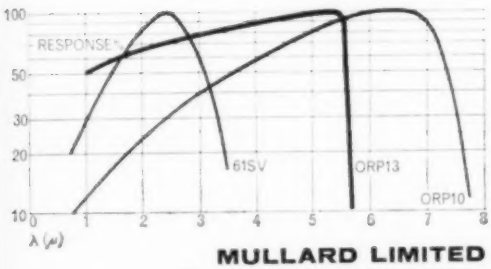

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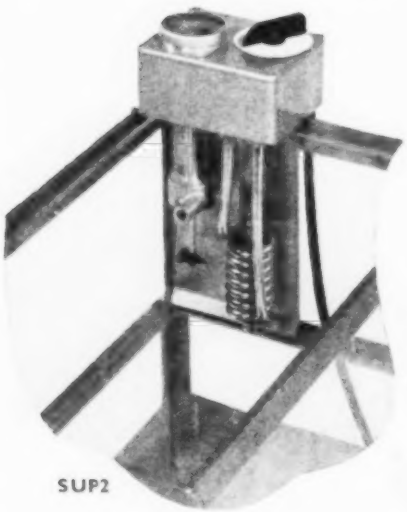

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